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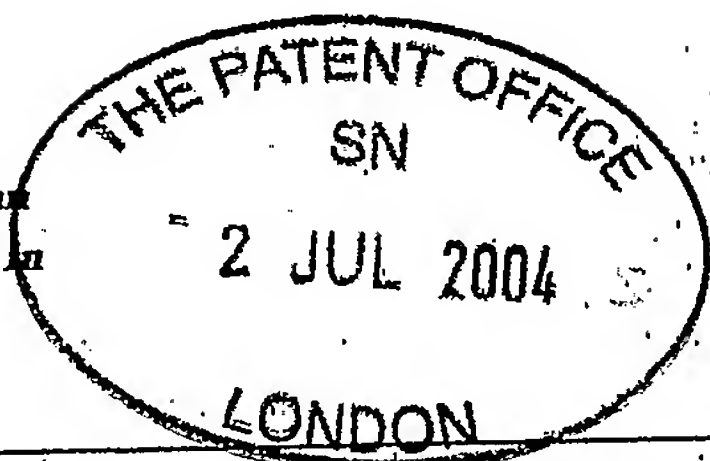




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IK/CEW/24438 - IK/CEC/24437 - 01

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P01/7700 0.00-0414991.0 NONE

3. Full name, address and postcode of the or of  
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Patents ADP number (if you know it)

If the applicant is a corporate body, give the country/state of its incorporation

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United Kingdom  
United Kingdom

8902645001

4. Title of the invention

Load-Carrying Apparatus

5. Name of your agent (if you have one)

"Address for service" in the United Kingdom to which all correspondence should be sent (including the postcode)

MATHYS & SQUIRE  
100 Gray's Inn Road  
London WC1X 8AL  
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Patents ADP number (if you know it)

1081001 ✓

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Country

Priority application number  
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Date of filing  
(day / month / year)

UNITED KINGDOM

0406272.5

19 MARCH 2004

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application

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Claim(s)

21

Abstract

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Statement of inventorship and right to grant of a patent (Patents Form 7/77)

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11.

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2 July 2004

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1  
**Load-Carrying Apparatus**

**DUPLICATE**

The present invention relates to the field of load-carrying apparatus, for example for the storage and transportation of goods, including methods for manufacturing such apparatus. In particular, but not exclusively, the invention relates to apparatus such as freight containers, pallets and cable reels and methods for manufacturing the apparatus.

Apparatus for storing and transportation of goods, particularly bulk goods, has to be robust enough to withstand the high impact stresses and adverse environmental conditions that it may encounter during normal operation.

Wooden pallets for storing and transporting goods are well known in the art and are defined by standards such as ISO Standard No. 6780.

Freight containers, for example shipping containers, are well known in the art and are used to transport freight securely and conveniently. To ensure containers can withstand the corrosive environment and the temperatures and stresses to which a container may be subjected in normal operation, the requirements for such containers are strictly defined by industry standards such as ISO 1496-1:1990 and ISO 668:1995 and, as required by the standard, prior art containers are manufactured from steel and/or aluminium.

However, steel containers suffer from a number of disadvantages. In particular, the weight of the container itself must be included when considering the gross laden weight for transport purposes and the high density of steel may mean that a large proportion of the weight of the laden container comprises the container itself.

Since the structural integrity and reliability of a steel container is very important, the working life of a steel container is often short, for example about 5 years, or about 7-10 years if the container owner is willing to repair and maintain the container, although it is often not efficient to do so. Steel containers require painting to protect them from rust, particularly in the corrosive environment in which they often operate,

for example they maybe subject to salt water during shipping and may encounter corrosive chemicals or oils during use. Containers may also be subject to high temperatures, particularly during shipping, for example temperatures of up to about 50°C are not uncommon, and steel containers easily absorb this heat and conduct it to their contents and surrounding containers. This may damage the contents of the containers and may make it more difficult to maintain refrigerated containers at a low temperature.

An additional problem with steel containers is that it is difficult to determine or verify the contents of a container without opening the container to view the contents. It is not possible to use remote imaging techniques, such as X-rays, to determine the contents of the container remotely and to ensure that nothing is hidden in the container. Hence it is difficult to detect containers that constitute a security risk or that are being used to transport illicit or undesirable goods.

15

Aspects of the invention are set out in the independent claims and preferred features are set out in the dependent claims.

According to the present invention there is provided a pallet element comprising a platform having an upper surface and a lower surface and a plurality of feet depending from the lower surface of the platform and wherein:

20

a single pallet element provides a single-sided pallet having feet of a height sufficient to allow lifting by a forklift truck;

25

a first said pallet element is arranged to couple to a second said pallet element to provide a double-sided pallet having a total height less than double the height of a single pallet element.

30

Hence the same pallet elements may be used flexibly, as needed, as single-sided or as double-sided pallets. For example, single-sided pallets may be used for lighter-duty of single-use work and double-sided pallets may be more suitable for heavy-duty work or for repeated use. As described in more detail below, one of the pallet elements is preferably rotated to form the double-sided pallet, so it is clear that, in this

orientation, the upper surface of the pallet platform would form the outer surface of the double-sided pallet and would lie below the lower surface.

5 Preferably, the first and the second pallet elements couple to provide a double-sided pallet wherein the feet of both the first and the second pallet are arranged between the platforms of the pallet elements. Hence one pallet is rotated so that the upper surfaces of the platforms of the pallets form the outer surfaces of the double-sided pallet.

10 In a preferred embodiment, the pallet elements are arranged to couple on presenting opposed elements appropriately located without further fixings or adhesives. Hence it is straightforward to assemble and disassemble the double-sided pallet.

15 Providing a single pallet element of a sufficient height to allow lifting by a forklift truck allows the single pallet element to be used alone as a single-sided pallet. Preferably, the height of single pallet element is substantially equal to the height of a standard pallet. The height of a standard pallet defined by the International Organisation for Standardization is defined in ISO Standard No. 6780. Preferably, the height of a single pallet element is at least around 100mm.

20 Preferably, in a double-sided pallet, the feet of the first pallet element interleave at least partially with the feet of the second pallet element.

25 In a preferred embodiment, the height of a double-sided pallet is substantially equal to the height of a single-sided pallet. Preferably, the height of a double-sided pallet is substantially equal to the height of a standard pallet. This may allow both double-sided and single-sided pallets to be manoeuvred using the same, standard equipment, for example using a standard forklift truck. Preferably, the height of a double-sided pallet is less than around 200mm.

30 Further preferably, the difference in height between a double-sided pallet and a single-sided pallet is substantially equal to the height of the platform of a pallet element.



Further preferably, the difference in height between a double-sided pallet and a single-sided pallet is less than the height of the platform of a pallet element.

5 Preferably, the height of the feet supporting the platform of a single-sided pallet is substantially equal to the spacing between platforms of a double-sided pallet.

10 Preferably, the first pallet element is coupled to the second pallet element by inserting the feet of at least one pallet element into recesses formed in the lower surface of the platform of the other pallet element. This may allow the heights of the single and double-sided pallets to be substantially the same and may advantageously provide means by which the pallet elements may be coupled together. Preferably, the feet of at least one pallet element latch or clip into the recesses in the lower surface of the other pallet element.

15 In one embodiment, the recesses in the lower surface of the platform comprise deformable teeth, wherein the deformable teeth latch around the feet of the opposing pallet element to retain the feet in the recesses.

20 In an alternative embodiment, the feet of each pallet element comprise foot elements, the foot elements of each foot being arranged to interleave with corresponding foot elements in the opposing foot. Hence at least some of the feet may interleave on a microscale with the opposing feet of the other pallet element. For example, the feet may include slots into which corresponding prongs of the feet of the opposing pallet element may be inserted. Pallets may be provided with some feet having foot  
25 elements that interleave on the microscale and some feet that interleave on the macroscale as described above.

In a preferred embodiment, at least one foot is arranged substantially at each corner of the platform.

30

Preferably, at least one foot is arranged substantially at the centre of the platform.

Further preferably, at least one foot is arranged substantially at the centre of each edge of the platform.

5 In a preferred embodiment, the feet of the pallet elements are arranged so that, on rotation of one pallet element about an axis through the plane of the platform of the pallet, a male configuration of feet on one pallet element mates with a female configuration of feet on the opposing pallet element.

10 Preferably, at least some of the feet of the pallet are arranged on the platform rotationally asymmetrically about at least one axis of rotation passing through the centre of the plane of the platform of the pallet and parallel to an edge of the pallet.

15 In one embodiment, one male configuration of feet comprises a single foot and a corresponding female configuration of feet comprises two feet separated by a gap, wherein the gap is sized to accommodate a single foot.

In one embodiment the pallet element is substantially rectangular.

20 Preferably, when one pallet element is rotated in an axis in the plane of the pallet platform and perpendicular to the elongate axis of the pallet platform, the feet of the pallet element interleave with the feet of a second pallet element.

Preferably, when the first pallet is rotated, the feet of the first pallet are offset relative to the feet of the second pallet.

25

In one embodiment, a male configuration of feet comprises an odd number of feet and a female configuration of feet comprises an even number of feet.

30 Preferably, the feet in the male configuration and the feet in the female configuration are mutually offset when a first pallet element is rotated and positioned over a second pallet element so that the platforms are aligned.

In one embodiment, feet in the corners of the pallet comprise male or female configurations of feet and feet in the along the centre lines of the pallet are mutually offset from the centre.

- 5 In a preferred embodiment, the pallet elements are rotationally moulded.

Further preferably, each pallet element is rotationally moulded substantially in one piece.

- 10 Preferably, the pallet elements are manufactured substantially from a filled plastics material.

Preferably, the filler comprises a mineral filler material.

- 15 Advantageously, the feet of each pallet element are formed integrally with the platform of the pallet element.

- 20 Preferably, the feet are tapered from a maximum width at the platform of the pallet element. This may allow the feet to be interleaved or stacked in a nested configuration more easily and may allow easier access for a forklift truck.

Further preferably, at least one side of at least one tapered foot of the pallet is concave. This may allow nested pallets to be released more easily from their nested configuration.

25

Preferably, recesses are provided in the upper surface of the platform of the pallet. Further preferably, the recesses in the upper surface correspond to the position of the feet of a pallet element. Hence the feet of stacked pallet elements may fit into the recesses in the upper surface of the pallet element below.

30

In a preferred embodiment, at least one foot is hollow.



Preferably, the recesses in the upper surface extend through the platform from the upper surface of the pallet element into the feet.

5 Preferably, pallet elements form a nested configuration when stacked on top of each other in the same orientation.

10 Further preferably, in a nested configuration, the feet of one pallet element are inserted into recesses in the corresponding feet of a second pallet element. This may allow the pallets to stack together in a closely nested configuration and hence advantageously significantly reduce the volume taken up by unloaded pallets.

15 In a preferred embodiment, the feet are arranged to enable the blades of a forklift truck to engage the pallet from any one of four directions. In an alternative embodiment, in particular if the pallet is rectangular, it may be possible to lift the pallet from only two directions.

In a preferred embodiment, at least a portion of the pallet element comprises an outer skin layer.

20 Further preferably, at least a portion of the pallet element comprises an inner layer having a different composition to the outer skin layer.

Preferably, the inner layer comprises a foaming agent.

25 In one embodiment, the pallet element further comprises a remotely readable tag, preferably an RFID tag. The tag may be used to store and provide details of the load of the pallet or its location or ownership details.

30 In a preferred embodiment, the platform of the pallet element comprises a substantially continuous surface. This may allow small items to be carried on the pallet.

Preferably, the platform of the pallet element comprises a textured surface. This may increase the ability of objects to grip the surface of the pallet and reduce slippage during transportation.

- 5 A method of assembling a double-sided pallet using two pallet elements, each pallet element comprising a platform and a plurality of feet depending from the platform, the method comprising:

rotating the first pallet element about an axis in the plane of the pallet platform;

- 10 arranging the second pallet element on top of the first pallet element so that the feet of both of the pallet elements lie between the platforms of the pallet elements and the feet of the pallet elements are interleaved;

coupling the second pallet element to the first pallet element.

- 15 In a preferred embodiment, the step of coupling comprises applying pressure to the pallet elements.

- Further preferably, applying pressure comprises applying a force of less than around 1000N, preferably less than around 500N, or applying an impact from a hammer of  
20 less than 10Ns.

Preferably, coupling comprises coupling the pallet elements without adhesives or fixings.

- 25 According to a further aspect, there is provided a method of manufacturing a plurality of pallets comprising:

inserting a feedstock comprising a filled plastics material into a mould;

rotating and heating the mould to rotationally mould a plurality of pallets;

releasing the plurality of pallets from the mould

- 30 separating the moulded plurality of pallets into single pallets.

In one embodiment, the method further comprises inserting a second feedstock into the mould to form an inner layer within the pallet.

Preferably, the second feedstock includes a foaming agent to form a foamed inner layer.

- 5 In one embodiment, separating the moulded plurality of pallets comprises punching or cutting the pallets out of a sheet of moulded pallets.

According to a further aspect, there is provided a method of distributing pallets comprising arranging layers of pallets in a nested configuration in a container,  
10 shipping the container to a predetermined destination, removing the pallets from the container.

Preferably, the pallets comprise pallet elements according to the aspect described above or any of its preferred features.

15

Preferably, the pallets and the container are rotationally moulded.

In one embodiment, the layers of pallets are provided in sheets and the method further comprises cutting the sheets of pallets into individual pallets.

20

According to one aspect there is provided a rotationally-moulded load-carrying apparatus for carrying a load of at least 50 kilograms, wherein the apparatus is manufactured substantially from a filled plastics material comprising:

- at least 10% by weight of a polymer;  
25 at least 10% by weight of a mineral filler material.

In some cases, up to 90% by weight of the remainder of the composition may comprise filler. However, a number of other components may be included in the composition. In particular, a component to unify the polymer and the filler may be  
30 provided, or a unifier may be present in the filler or polymer. Preferably at least 1% by weight and less than 20% by weight unifier is provided. Further components that may be incorporated in the material include a colourant, a flame retardant and a stabiliser, for example a UV stabiliser.

Manufacturing load-carrying apparatus using a plastics based material may provide a number of advantages, as set out in more detail below. However, it has been found that containers manufactured substantially from a purely plastics material are not sufficiently resilient to withstand the temperatures and stresses to which they may be subjected during normal use. The addition of a filler may solve this problem by increasing the strength and structural integrity of the apparatus.

Forming the apparatus from a plastics material may be advantageous since the unladen weight of the plastic apparatus may be less than that the equivalent prior art apparatus, which may be manufactured from materials such as steel or wood. This may allow a user to use the apparatus to carry a greater weight of goods, whilst keeping the gross weight constant, or may allow a transportation operator, for example a shipping merchant, to pack more load-carrying apparatus onto a ship or to save fuel in transportation of the apparatus.

In addition, apparatus manufactured from a plastics based material will not suffer from the problems associated with rusting and hence such apparatus may not require painting. These properties may enable the expected lifetime of the apparatus to be increased. For example, the expected lifetime of a prior art steel shipping container may be about 5 years for a steel container whereas a lifetime of about 25 years is reasonable for a plastics-based container. A further advantage may be that, when the plastic apparatus is brought out of operation, it may be broken up and ground and the material may be incorporated into new products, for example the material may be recycled to form parts of new apparatus.

A further advantage of such apparatus is that it may be possible to determine, verify or monitor the contents of the apparatus using a remote sensing technique, such as X-rays or thermo-sensing, since it may be possible for such radiation to pass through the material of the apparatus. This may allow authorities to ensure that the contents of the apparatus do not comprise a security risk and may allow authorities to detect illicit or undesirable goods or to verify that the contents of the apparatus correspond to the declared contents.

A further property of the apparatus may be that the plastics material has better insulating properties than the material used for the equivalent prior art apparatus, for example steel. This may allow the contents of the apparatus to be better insulated from high or low temperatures than in the prior art apparatus. This may enable, for example, refrigerated containers to be provided more easily and such containers may require less power to be maintained at a constant temperature.

Rotationally moulding the apparatus may allow the apparatus to be formed with few internal stresses in the material. This may lead to a stronger load-bearing apparatus than would be provided by other forms of moulding.

Preferably, the mineral material comprises a silicate or comprises a carbonate material. In a highly preferred embodiment, the filler comprises sand, preferably consists essentially of sand. The sand is preferably dredged sand. Sand is readily available at consistent granularity and can form a surprisingly effective filler. Another advantage of using sand as part of the filler material is that it may provide additional security for the container, since container walls that include sand may be difficult to cut through, since the sand in the composition is likely to blunt quickly any machinery that is used to attempt to cut through the material. In an alternative embodiment, the filler may comprise calcium carbonate.

Further, the filled material described herein is likely to be flame retardant, although a further flame retardant component may also be incorporated into the filled material.

In a preferred embodiment, the polymer comprises polyethylene. The polymer used may depend on the apparatus being manufactured and other polymers, such as PVC or PVA may be used. However, polyethylene may provide a hard-wearing, resistant material for use in a wide range of apparatus.

More preferably, the polymer comprises High Density Polyethylene (HDPE). Preferably, the material comprises at least 25% by weight filler.



Preferably, the material comprises at least 25% by weight polymer.

5 In a highly preferred embodiment, the material comprises from about 30% to about 70% by weight polymer and from about 70% to about 30% by weight filler. The polymer and the filler may comprise 100% of the material or other components may be included in the material as described herein and the additional components may comprise the remaining % weight of the material.

10 In a preferred embodiment, the filled plastics material further comprises a unifier. The unifier may be provided to bind the polymer and the filler together.

Preferably, the filled plastics material comprises at least about 0.1% by weight unifier. Preferably, the filled plastics material comprises less than about 10% by weight unifier.

15

More preferably, the filled plastics material comprises at least about 0.25% by weight unifier. More preferably, the filled plastics material comprises less than about 5% by weight unifier.

20 In a preferred embodiment, the unifier is pre-mixed with the filler before the filler is mixed with the polymer.

25 In one embodiment, the unifier may comprise an internal lubricant. Alternatively or additionally, the unifier may comprise an external lubricant. The internal lubricant may act to improve lubrication between the polymer chains.

In a preferred embodiment, the internal lubricant comprises a fatty acid amide. More preferably, the internal lubricant comprises a straight or branched C<sub>12</sub>-C<sub>24</sub> fatty acid amide. More preferably, the internal lubricant comprises steramide.

30

In a preferred embodiment, the external lubricant comprises a stearate.

Preferably, the unifier comprises less than 20% by weight internal lubricant. More preferably, the unifier comprises about 10% by weight internal lubricant.

Preferably, the filler comprises at least one of:

- 5 a silicate material, preferably sand;  
ash;  
a carbonate material, preferably calcium carbonate;  
a salt, preferably sodium chloride.
- 10 The filler may comprise a mixture of filler materials. Preferably, the filler material is inert, more preferably the filler material is inorganic, although organic fillers, such as wood flour, peanut hulls, ground straw or animal litter may be used. Preferably, the filler is provided or is ground into small particles, since this may provide a more uniform material. Dredged sand may be used in preference to desert sand since the
- 15 particles of dredged sand are finer than those of desert sand.

In a preferred embodiment, the apparatus is rotationally moulded substantially in one piece. Moulding the apparatus substantially in one piece may advantageously allow the product to be produced without substantial post-processing of the moulded

20 product. Parts of the apparatus (for example, the doors of a container) may be moulded separately and coupled to the apparatus after the main moulding process.

In one embodiment, the apparatus comprises a freight container. A freight container manufactured as described herein may provide the advantages outlined above. In

25 particular, the plastics container may be lighter and may be more durable and more environmentally sustainable than a prior art steel container. In addition, it may be possible to X-ray or obtain a thermal image of the plastics container to determine its contents and increase security.

30 In one embodiment the freight container comprises an elongate freight container having a length of at least 5m, e.g. e.g. the container may comprise a 20 foot (about 6m) container.



In a further embodiment, the freight container may comprise an elongate freight container having a length of at least 10m, e.g. the container may comprise a 40 foot (about 12m) high-cube container. This may allow the container to be used in the same way as an existing steel container that meets the standards for a 40' high cube container. For example, the plastics 40' container may be stacked with prior art containers and may be transported using the same apparatus and fixing means as a prior art container, for example the container may be fixed onto a transport lorry in the same way as a prior art container. As will be appreciated by one skilled in the art, however, the container may comprise storage and transportation apparatus of any shape or size.

Preferably, the thickness of the walls of the container is less than about 90mm. Hence the container may have thinner walls than a prior art steel container. In one embodiment, the walls may have a thickness of about 70mm.

Preferably, the filler comprises a light-coloured material. This may enable the apparatus to be manufactured in a light colour without requiring painting or expensive pigments. For a container, manufacturing the container in a light colour may help the container to maintain a lower temperature when it is exposed to high temperatures, particularly to radiated heat such as intense sunlight.

In one embodiment, the apparatus comprises a pallet. A plastics-based pallet may advantageously provide an alternative to the prior art wooden pallets. The plastic pallet may have a longer usable life than a wooden pallet, since the plastic pallet may be stronger and more durable than a wooden pallet. Hence the plastic pallet may be more environmentally sustainable than a wooden pallet.

Preferably, the pallet is moulded substantially in one piece. Preferably, a plurality of pallets may be moulded in a single moulding operation.

Preferably, the pallet comprises a platform and a plurality of feet depending from the platform.

More preferably, the feet are arranged to enable lifting equipment to engage the pallet from any one of four directions. Hence the pallet may be a four-way-access pallet, which may be lifted from any one of four directions, for example by a fork-lift truck.

- 5 Preferably, the feet of the pallet are regularly spaced over the lower surface of the platform. Bracing members may be provided between the feet of the pallet.

Preferably, at least one foot is arranged substantially at each corner of the platform of the pallet. Hence, each corner of the platform may be supported.

10

More preferably, at least one foot is arranged substantially at the centre of the platform of the pallet. This may further strengthen the platform pallet at the centre.

- 15 Preferably, at least one foot is arranged substantially at the centre of each edge of the platform of the pallet. Hence a total of 9 feet are preferably provided for each pallet. Four feet may be provided at the corners of the pallet, a further four feet may be provided at the centre of each edge of the pallet and a further, 9<sup>th</sup> foot may be provided under the centre of the platform of the pallet.

- 20 In a preferred embodiment, each foot has a recess in the lower surface of the foot. This may advantageously reduce the weight of the pallet, without reducing the strength of the pallet. In addition, the pallet may be formed without requiring a large cavity in each foot to be evenly filled with an inner layer.

- 25 Preferably, the pallet comprises an outer skin layer having an upper surface and a lower surface.

- 30 More preferably, the upper and lower surfaces of the outer skin layer are arranged to abut each other over at least a portion of the pallet surface. In one embodiment, the upper and lower surfaces may form a cavity over the feet of the pallet but may abut each other, e.g. the surfaces may be formed substantially without a gap between them, over the platform areas of the pallet. The outer skin layer may be the only layer of the pallet and the cavities formed between the upper and lower surfaces may be filled

with air. Alternatively, the cavities may be filled with a further material, such as a foamed plastics material or a filled plastics material.

5 In a preferred embodiment, the pallet further comprises an inner layer having a different composition to the outer skin layer. Providing an inner layer within the outer skin may add further strength and rigidity to the pallet.

10 Preferably, the inner layer comprises a foaming agent. Providing the layer as a foam layer may ensure that the additional layer does not add significantly to the overall weight of the pallet.

15 In an alternative embodiment, the inner layer comprises at least 40% by weight of a filler. Using a highly filled inner layer may enable the pallet to be strengthened, but the highly-filled layer may be inexpensive.

In a preferred embodiment, the feet of the pallet are moulded integrally with the platform.

20 Preferably, the pallet has a length of at least 800mm. In one embodiment, the pallet may have dimensions corresponding to those of a standard pallet, that is about 1020x1220x120mm (40x48x5 inches).

Preferably, the feet of the pallet have a width greater than about 30mm.

25 In a further embodiment, the apparatus comprises a cable reel.

In a highly preferred embodiment, the apparatus comprises a plurality of layers.

30 Preferably, the composition of the filled plastics material differs between the layers. This may allow properties of a plurality of compositions to be incorporated into the apparatus.

Preferably, the composition of a first layer of the apparatus is optimised to provide an outer skin layer. Preferably, the outer skin layer is manufactured to be durable enough to withstand the conditions and the chemicals to which the apparatus may be subjected during normal use.

5

Preferably, the outer skin layer comprises more than about 20% by weight filler. More preferably, the outer skin layer comprises less than about 80% by weight filler. This may ensure that the outer skin layer is not too brittle.

10 Preferably, the outer skin layer comprises more than about 50% by weight polymer, more preferably, the outer skin layer comprises about 60% by weight polymer.

In a preferred embodiment, the composition of a second layer of the apparatus is optimised to provide an inner layer. The inner layer may be formed within the outer  
15 skin layer and may comprise a highly-filled or a light-weight layer.

In a preferred embodiment, the inner layer comprises a polymer. Hence the inner layer may not contain a filler material. This may be advantageous since a polymer, particularly a foamed polymer, may be lighter than a filled polymer.

20

In an alternative embodiment, the inner layer comprises a polymer and a filler.

In one embodiment, the inner layer comprises more than about 30% by weight filler. A highly-filled inner layer may be provided, since it will be protected by the outer  
25 skin layer. Hence the inner foam layer may have different surface properties to the outer skin layer, since it will not be subjected to external conditions. A highly filled, relatively dense, inner layer may be provided inexpensively, for example using a low-grade filler.

30 More preferably, the inner layer comprises more than about 50% by weight filler. In a preferred embodiment, the inner layer comprises about 60% by weight filler.

In a preferred embodiment, the inner layer comprises a greater amount of filler by weight than the outer layer.

5 In a highly preferred embodiment, the inner layer comprises a foaming agent, preferably the foam layer is about 50% foamed. This may mean that the inner layer is a light layer and does not increase significantly the overall weight of the apparatus.

10 In some embodiments, the filled plastics material further comprises a pigment. Advantageously, the apparatus may be coloured to any colour required simply by adding a pigment to the feedstock. This may allow apparatus of a consistent colour to be produced without requiring the further step of painting the apparatus. In some embodiments, the product formed from the material, for example the container or the pallet, may further be printed on.

15 In a preferred embodiment, the apparatus incorporates a remotely readable Identification (ID) tag, preferably an RFID tag. The tag may be used to store information about the container and/or the contents of the container. For example, details of the contents of the container, its source, its destination, and the owner of the contents of the container may be recorded.

20

Preferably, the ID tag is moulded into the surface of the apparatus.

25 In some embodiments, the filled plastics material further comprises a stabiliser, preferably a UV stabiliser. This may allow the material to be exposed to Ultra-Violet radiation, for example sunlight, without degrading the plastics material.

In some embodiments, the filled plastics material further comprises a plasticizer.

30 According to a further aspect, there is provided apparatus for sealing a freight container comprising sealing means manufactured from a plastics material, wherein the plastics material is soluble in salt-water.



A problem in the container freight shipping industry is that containers are often lost overboard from container ships. The lost containers often contain air and other matter less dense than water and, since the containers are substantially air-tight, the containers may float on or just below the surface of the water. This may cause a hazard for other shipping in the area. The aspect described above may therefore allow a container lost overboard to lose its seal, to fill with water and to sink, which may reduce or remove the potential hazard caused by the container.

Preferably, the plastics material comprises PVA or PVOH.

10

Preferably, the plastics material further comprises a filler and/or a unifier.

Preferably, the seal is arranged to dissolve in salt water over a period of about 5 days.

15 According to a further aspect, there is provided a method of manufacturing apparatus for storage or transportation of loads greater than about 50 kilograms, the method comprising rotationally moulding the apparatus from a filled plastics material comprising a polymer, a filler and a unifier.

20 According to a further aspect, there is provided X-ray apparatus for forming an X-ray of the contents of a load-carrying apparatus for carrying loads of at least 50 kilograms and manufactured from a filled plastics material, comprising:

a scanning area;

energy delivery means for providing energy of a suitable frequency spectrum and

25 intensity to penetrate at least 20mm of the filled plastics material;

energy detecting means to detect reflected energy.

According to a further aspect, there is provided thermal imaging apparatus for forming a thermal image of the contents of a load-carrying apparatus for carrying loads of at least 50 kilograms and manufactured from a filled plastics material, comprising:

30

a scanning area;

energy detection means for detecting thermal energy transmitted from within the load-carrying apparatus.

Preferably, the scanning area has a maximum dimension of at least 1m. In one  
5 embodiment, the scanning area has a maximum dimension of at least 2m.

Preferably, the filled plastics material comprises at least 10% by weight of a mineral filler, preferably a silicate or a carbonate filler.

10 In one embodiment, the load-carrying apparatus comprises a freight container. Hence the contents of containers may be determined using the imaging apparatus.

In one embodiment, the load-carrying apparatus has a length of at least 5m. In a further embodiment, the load-carrying apparatus has a length of at least 10m.  
15

A further aspect provides a method of rotationally moulding a product from a filled plastics material comprising:

providing a mould for the product defining a void corresponding to at least a portion of the required shape of the product;

20 loading a first feedstock having a first composition comprising a polymer and at least 10% by weight of a mineral filler into the mould;

heating the mould;

rotating and/or rocking the mould about at least two axes to coat the internal walls of the mould with a layer of the first feedstock;

25 cooling the mould;

releasing the product from the mould.

The method described above may advantageously provide an efficient method of rotationally moulding products.

30

Preferably the method further comprises providing heating means adjacent to the walls of the mould and heating the mould using the heating means. Applying heat using heating means adjacent to the walls, such as one or more burners, for example



gas or oil burners, or one or more electric heated plates, may allow the mould to be heated evenly over its whole surface without requiring the mould to be placed in and rotated within an oven. Hence the mould may be heated more quickly, since it is not necessary to heat a whole oven and the energy-efficiency of the process may also be increased.

Preferably, the method comprises providing cooling means adjacent to the walls of the mould and cooling the mould using the cooling means. Similarly, providing cooling means adjacent to the walls, such as a stream or jet of water or cooled air, may increase the energy efficiency and decrease the moulding time for the product, since the mould may be cooled directly, without requiring a moulding oven to be cooled.

In addition, using heating and cooling means adjacent to the mould walls may allow moulds of any size or shape to be used without the user requiring a moulding oven of a corresponding size.

Preferably, the heating means comprise a plurality of burners. Preferably, the burners comprise gas or oil burners.

Preferably, the cooling means comprises at least one supply of water, for example, a stream, a pool or a jet of water.

Preferably, the mould is a generally elongate mould and the method comprises rotating the mould about a first axis substantially parallel to the axis of elongation of the mould and rocking the mould about a second axis substantially orthogonal to the first axis.

In a preferred embodiment, rocking the mould comprises rocking the mould through a portion of a circle to a maximum angle from the horizontal of less than about  $30^\circ$ .

Preferably, the mould is rocked to a maximum angle from the horizontal of about  $15^\circ$ . In some embodiments, particularly if the mould is a small mould, the mould may be rocked to an angle greater than about  $30^\circ$ , for example the mould may be rocked to about  $45^\circ$ .

Preferably the mould is rocked at a rate of less than about 6 rocking cycles per minute. Preferably, the mould is rocked at a rate of about 4 cycles per minute.

- 5 Preferably, the mould is rocked at a rate of greater than about 1 rocking cycle per minute.

Preferably rotating the mould comprises rotating the mould at a rate of less than about 10 revolutions per minute. More preferably around 4 revolutions per minute.

- 10 Preferably, rotating the mould comprises rotating the mould through 360°. Alternatively, the mould may not be rotated through a full circle. The mould may be constantly rotated in the same direction, or the direction of rotation may be reversed periodically.

- 15 In some embodiments, particularly if the mould is a small mould, the mould may be rocked and/or rotated at a faster rate. However, except for small moulds, the cycle rate is likely to be less than about 30rpm.

- 20 Using a rotation or rocking rate that is too slow may lead to an uneven distribution of feedstock within the mould, since gravitational effects may dominate the motion of the feedstock. However, using a rotation or rocking rate that is too fast may not be energy-efficient and centrifugal effects may also lead to an inferior product.

- 25 Hence it is preferably not necessary to rotate or to rock the mould at a high rate. The rotating and rocking of the mould is preferably a continuous motion, but may not be continuous in some embodiments.

- 30 In a preferred embodiment, the mould comprises an inner mould portion and an outer mould portion, wherein the inner mould portion is positioned within the outer mould portion and wherein the first feedstock is inserted between the outer mould portion and the inner mould portion. Hence the product may be formed between the two moulds. This may allow the inner surface of the product to be provided with a predetermined shape and may allow the thickness of the product to be controlled. The

feedstock is preferably inserted between the moulds and the moulds are heated and rotated together to ensure that the melted feedstock covers the surfaces of both of the moulds.

- 5 Preferably, the method further comprises providing heating means within the inner mould portion. Hence the inner mould portion may be heated to provide a more even temperature distribution throughout the moulding volume.

10 Preferably, the method further comprises maintaining the heating means at a substantially constant distance from the walls of the outer mould portion as the mould is rotated. This may enable all parts of the mould to be heated evenly and hence may encourage a more even distribution of the plastics material within the mould.

Preferably, the method further comprises, before cooling the mould:

- 15 loading a second feedstock, having a second composition, into the mould;  
rotating the mould to form a second layer of the second feedstock.

Preferably, the composition of the first layer is optimised to provide an outer skin layer.

20

Preferably, the composition of the second layer is optimised to provide an inner layer.

25 In a preferred embodiment, the second feedstock comprises a foaming agent. Preferably, the second feedstock becomes foamed after insertion into the mould on the application of heat to the mould. Hence the feedstock may be distributed evenly within the mould before being foamed. Aeration of the feedstock may release nitrogen or another similar, preferably substantially inert gas. Preferably, a foaming agent, such as sodium bicarbonate, may be incorporated into the second feedstock.

- 30 Preferably, the second feedstock comprises a higher proportion of filler than the first feedstock. In one embodiment, the second feedstock comprises at least 50% by weight of a mineral filler. However, as described for the pallet above, the second feedstock

may not contain a filler but may simply be a polymer, preferably a foamed polymer. Alternatively, the second feedstock may be highly filled.

5 The mineral filler preferably comprises a silicate filler, such as sand, or a carbonate filler, such as calcium carbonate.

10 In one embodiment, the product may comprise at least one of: a freight container, a pallet, a cable reel or a panel. Preferably, a plurality of products are produced in a single moulding operation.

15 In one embodiment, the method may further comprise positioning elements of the product within the mould before the feedstock is inserted and over-moulding the elements into the product. This may further reduce the amount of post-processing required for the product and ensure that the additional components are securely fixed into the product.

In one embodiment, the product comprises a freight container and the elements comprise one or more of:  
a metal frame;  
20 door securing means;  
strengthening elements; or  
corner lifting elements.

25 In a highly preferred embodiment, the product is moulded substantially in one piece.

30 Preferably, releasing the product from the outer mould portion comprises moving the walls of the outer mould portion apart and away from the moulded product. Hence the outer mould portion may be removed from the moulded product and the product may be removed from the inner mould portion. This may advantageously allow the product to be formed with shaper and more well-defined edges, since prior art moulding techniques have previously required the product to be removed from a tightly-fitting mould, so it has been necessary to form products with rounded edges to allow the product to be removed from the mould more easily.

A further aspect may provide a filled plastics material comprising:

a polymer;

at least 10% by weight of a mineral filler;

5 a unifier comprising stearate.

Preferably, the unifier further comprises an internal lubricant, preferably steramide.

More preferably, the steramide comprises Chrodamide S Powder.

10

Preferably, the stearate comprises Calcium Stearate.

Preferably, the unifier comprises more than 5% by weight steramide. More preferably, the unifier comprises about 10% by weight steramide.

15

Preferably, the unifier comprises more than 80% by weight stearate. More preferably, the unifier comprises about 90% by weight stearate.

20

In a preferred embodiment, the polymer comprises polyethylene. More preferably, the polymer comprises High Density Polyethylene (HDPE).

Preferably, the filler comprises at least one of:

a silicate material, preferably sand;

ash;

25 a carbonate material, preferably calcium carbonate;

a salt, preferably sodium chloride.

A mixture of filler materials may be used, as described above.

30

Preferably, the filled plastics material comprises at least 0.1% by weight unifier. More preferably, the filled plastics material comprises about 1% by weight unifier.

According to a further embodiment, there is provided apparatus for rotationally moulding, from a filled plastics material, a load-carrying apparatus for carrying a load of at least 50 kilograms, the apparatus comprising:

- 5 a mould defining a void corresponding to at least a portion of the required shape of the product;
- means for receiving a first feedstock comprising a filled plastics material comprising a polymer and at least 10% by weight of a mineral filler;
- heating means;
- cooling means;
- 10 means for rotating and/or rocking the mould about at least two axes.

Preferably, the heating means are provided adjacent to the walls of the mould.

Preferably, the cooling means are provided adjacent to the walls of the mould.

15

In a preferred embodiment, the mould is a generally elongate mould and the apparatus further comprises means for rotating the mould about a first axis substantially parallel to the axis of elongation of the mould and means for rocking the mould about a second axis substantially orthogonal to the first axis.

20

Preferably, the mould comprises an inner mould portion and an outer mould portion, wherein the inner mould portion is positioned within the outer mould portion and wherein the first feedstock is inserted between the outer mould portion and the inner mould portion.

25

Preferably, the apparatus further comprises heating means within the mould, preferably within the inner mould portion.

In a preferred embodiment, the apparatus further comprises means for maintaining the  
30 heating means at a substantially constant distance from the mould.

In one embodiment, the outer mould portion has a length of at least 5m. Preferably, the outer mould portion has a length of at least 10m.



Preferably, the filled plastics material comprises at least 30% by weight of a mineral filler. Preferably, the filler comprises a silicate or a carbonate material.

- 5 Preferably, the apparatus is mounted over a pit and wherein at least one end of the outer mould portion is rocked into the pit.

10 Preferably, the means for receiving the feedstock comprises a series of apertures in the outer mould portion. Using a plurality of apertures may allow the feedstock to be inserted into the mould at a high rate. This may decrease the moulding cycle time and may reduce the amount of energy used in each moulding cycle. The feedstock may also be distributed more evenly throughout the mould. Using a series of apertures may be particularly advantageous when the second and any subsequent feedstocks are inserted, since the second feedstock may be inserted quickly and evenly within the first  
15 feedstock.

Preferably, the series of apertures is formed along at least one edge of the outer mould portion.

- 20 More preferably, the series of apertures is covered by at least one sliding gate valve.

According to a highly preferable embodiment, the internal surface of the sliding gate valve is coated in a non-stick material. This may allow a second or subsequent feedstock to be inserted within a first moulded feedstock. For example, an inner layer  
25 of a product may be inserted within an outer shell layer. This may be achieved since the first feedstock preferably does not adhere to the non-stick material, so an aperture in the feedstock layer may be provided when the gate is opened to allow the second feedstock to be inserted.

- 30 In a preferred embodiment, the apparatus comprises at least one hopper for storing the feedstock. Preferably, the hopper comprises dispensing means for dispensing a predetermined amount of the feedstock, wherein the predetermined amount comprises



the amount of feedstock required to rotationally mould at least one load-carrying apparatus.

Preferably, the apparatus further comprises filling means for loading the mould with a  
5 predetermined amount of the feedstock.

Preferably, the filling means comprises means for filling the feedstock via a series of apertures in the outer mould portion.

10 Preferably the means for filling the feedstock comprises at least one bucket having a series of apertures corresponding to the series of apertures in the outer mould portion.

More preferably, the bucket comprises a telescopic bucket having an adjustable length. This may enable the bucket to be transported to the moulding apparatus more  
15 easily.

In a preferred embodiment, the heating means comprises at least one gas burner.

Preferably, the cooling means comprises a jet of water. The water may be cycled  
20 through a cooling system or may be provided from a reservoir, for example from the sea.

According to a further aspect, there is provided a unifier for promoting binding and dispersion of a mineral filler and a polymer, wherein the unifier comprises a fatty acid  
25 amide.

Preferably, the fatty acid amide comprises a straight or branched  $C_{12}$ - $C_{24}$  fatty acid amide. More preferably, the unifier comprises steramide.

30 In a preferred embodiment, the unifier further comprises an external lubricant, preferably wherein the external lubricant comprises a stearate.

Preferably, the unifier comprises more than 80% by weight external lubricant. More preferably, the unifier comprises about 90% by weight external lubricant.

5 Preferably, the mineral filler comprises a silicate or a carbonate material, more preferably the filler comprises sand or calcium carbonate.

According to a further aspect, there is provided a rotationally-moulded load-carrying apparatus comprising:

- at least 10% by weight HDPE;
- 10 at least 10% by weight of a filler comprising sand;
- a unifier comprising a fatty acid amide;
- wherein the load-carrying apparatus comprises an inner layer and an outer layer, the layers having different compositions.

- 15 In one embodiment, the apparatus comprises an elongate container having a length of at least about 5m and a wall thickness of at least about 40mm.

In one embodiment, the apparatus comprises a pallet having a length of at least about 800mm.

- 20 Preferably, the inner layer comprises a foamed layer.

- 25 Aspects may be provided separately or in combination and features of one aspect may be applied to other aspects. Modifications, which would be obvious to one skilled in the art, may further be provided within the scope of the invention.

Embodiments of the invention will now be described with reference to the drawings in which:

- Fig. 1 illustrates a container and moulding apparatus according to one embodiment;
- 30 Figs. 2a and 2b are schematic diagrams of a further embodiment of a moulded container and moulding apparatus according to one embodiment;
- Fig. 3 is a schematic diagram of a further embodiment of a moulded container and moulding apparatus according to one embodiment;

Fig. 4 illustrates a further embodiment of moulding apparatus according to one embodiment;

Fig. 5 is a schematic diagram of a container according to one embodiment;

Fig. 6 illustrates one embodiment of a container manufactured according to the  
5 methods and apparatus described herein;

Fig. 7 is a schematic diagram of a reinforcing eyelet according to one embodiment;

Fig. 8 is a schematic diagram of a reinforcing eyelet moulded into a container according to one embodiment;

Fig. 9a is a schematic perspective view of the top of one embodiment of a pallet  
10 manufactured according to the methods and apparatus described herein;

Fig. 9b is a schematic perspective view of the bottom of one embodiment of a pallet manufactured according to the methods and apparatus described herein;

Fig. 10 is a schematic diagram of a pallet according to one embodiment;

Fig. 11 is a schematic diagram of a manufacturing plant for implementing the  
15 methods described herein;

Fig. 12 is a further schematic diagram of a manufacturing plant for implementing the methods described herein;

Fig. 13 is a schematic diagram illustrating the loading of feedstock into a moulding apparatus according to one embodiment;

Fig. 14 illustrates example moulding cycle times for a plastics-based filled compared  
20 to polyethylene;

Fig. 15 illustrates example impact strengths for a plastics-based filled compared to polyethylene;

Fig. 16 illustrates example tensile modulus results for a plastics-based filled material  
25 compared to polyethylene;

Fig. 17 illustrates one embodiment of a pallet element;

Fig. 18 illustrates a plurality of identical pallet elements stacked in different configurations;

Fig. 19 further illustrates a plurality of stacked, identical pallet element;

Fig. 20 illustrates a close-up view of the feet of three stacked pallet elements  
30 according to one embodiment;

Fig. 21 is a schematic diagram illustrating how a plurality of pallets may be moulded in a single mould;

Fig. 22 illustrates a portion of a mould that may be used in the manufacture of pallets according to one embodiment;

Fig. 23 illustrates a section of the mould of Fig. 22 in more detail;

Fig. 24 illustrates two pallets according to an alternative embodiment;

5 Fig. 25 is a schematic diagram of a cross-section through part of a mould for a pallet;

Fig. 26 is a schematic diagram of a cross-section through a part of a mould for a pallet;

Fig. 27 is a schematic diagram of a plan view of part of a mould for a pallet.

10 A wide variety of shapes and sizes of pallets may be formed using the methods described herein and the forms of some embodiments of pallets will now be described in more detail with reference to Figs. 17 to 27.

Fig. 17 illustrates one embodiment of a pallet that may be manufactured according to the techniques described herein. The pallet has a substantially rectangular upper surface or platform 1710 and a plurality of feet 1712 depending from the surface.

20 The feet 1712 may be moulded integrally with the platform 1710 of the pallet, which may allow the feet to be coupled securely to the pallet and reduce the complexity of the manufacturing process when compared to the process of forming the feet separately and attaching the feet to the platform of the pallet.

25 In the present embodiment, the pallet includes a foot assembly at each corner of the pallet 1714, an assembly at the centre of the pallet and an assembly in the centre of each edge of the pallet. Each foot assembly may comprise one or more feet depending from the pallet surface.

30 The feet of the pallet are preferably arranged so that the pallet may be accessed by lifting and manoeuvring equipment from any of its four sides, in particular, so that the blades of a forklift truck can fit underneath the pallet from any side or from at least two sides.

The feet of the pallet are preferably tapered from a widest point at the platform of the pallet. This may increase the ease of access for lifting equipment to fit between the feet of the pallet and may also make it easier to connect the pallet to another pallet, as described in more detail below, to form a double-sided pallet assembly.

5

The upper surface of the platform of the pallet 1710 is preferably provided with an uneven surface, which may increase the grip of the surface for objects placed on the surface. The platform of the pallet is preferably a substantially continuous surface, although holes may be provided in the surface to reduce the net weight of the pallets.

10 Providing a pallet with a substantially continuous surface may allow small objects to be carried on the pallets.

The feet of the pallet are preferably at least partially hollow. This may reduce the weight of each pallet without significantly reducing the pallet strength and hence may  
15 allow more goods to be loaded onto the pallet for a given gross weight. A hollow may be formed from the under-side of the feet or, as shown in Fig. 17, the hollow 1716 may be formed into the feet from the platform of the pallet. This may be advantageous in allowing the pallets to be stacked and nested, as described in more detail below.

20 The feet of the pallet are preferably arranged so that the pallet can be stacked with other pallets in a number of different configurations. For example, as shown in Fig. 18, the feet may be arranged so that the feet of a first pallet 1810, sitting directly on top of a second pallet, fit into the recesses 1812 in the platform of the second pallet. This may allow the pallets to be stacked in a secure and stable configuration. If the  
25 recesses in the feet are large recesses or hollows, then the unladen pallets may be stacked closely together in a nested configuration and the storage space required for unladen pallets may be reduced significantly.

The feet of the pallet may be arranged to be rotationally symmetrical so that the feet  
30 of a pallet fit into the recesses in the feet of a lower pallet even when one of the pallets is rotated through 180 degrees in an axis perpendicular to the plane of the platform.



If the feet are not arranged in a symmetrical configuration, as shown in Fig. 18, unladen pallets may be stacked without the feet of an upper pallet fitting into the recesses in the feet of a lower pallet by turning one of the pallets through 180 degrees. This may be advantageous since it may be easier for a forklift truck operator to manoeuvre the pallets if the pallets are not closely nested together. This feature may also give the user the options of nesting or not nesting stacked pallets.

As also illustrated in Fig. 18 and Fig. 19, a pallet may be combined with a second pallet to form a double pallet 1814, 1910. A double pallet may be formed by rotating one pallet through 180 degrees around an axis in the plane of the pallet and placing a second pallet over the inverted pallet so that both sets of feet of the two pallets lie between the pallet platforms. As illustrated in Figs. 18 and 19, the feet of the pallets 1912, 1914 are preferably arranged so that, when one pallet is inverted, the feet of the two pallets interleave so that each foot of both pallets touches the underside of the platform of the other pallet. Such a combination of pallets may be stronger and more rigid than a single pallet. A double pallet may be used to manoeuvre heavier loads or for more heavy-duty work.

As will be appreciated, a variety of arrangements of the feet of the platform may be provided to allow the feet of two platforms to interleave on formation of a double-sided pallet. The feet of the pallet are preferably arranged asymmetrically in at least one axis of rotation in the plane of the pallet. Arranging the feet asymmetrically in only one axis of rotation means that the feet of pallets only interleave to form a double-sided pallet in one orientation, but may allow greater flexibility in the arrangement of feet on the pallets and hence may provide a more robust pallet when it is used in the single-sided formation.

One or more feet may be arranged at each corner of the pallet, at the centre of the pallet and along the edges of the pallet and, at each point, the one or more feet may have a male or a female configuration. The arrangement of the feet is preferably such that, in the double-sided formation, feet with a male configuration correspond to opposing feet with a female configuration and hence fit together. As illustrated in Fig. 19, a male configuration of feet may comprise a single foot 1916 and a female

configuration of feet may comprise two feet 1918 with a gap in between sufficient to allow the foot of the opposing pallet to interleave between them. Other feet of the pallet, such as those shown along the centre line 1920 in Fig. 19, may be offset from the centre line or from the edge of the pallet. This may allow the feet of the pallet to interleave on formation of a double-sided pallet.

As illustrated in Fig. 20, the inner surfaces of the platform of each pallet may be provided with recesses 2010 corresponding to the position of the feet of the opposing pallet. This may reduce the likelihood of the two pallets moving or sliding relative to each other when they are in the double-pallet configuration. The recesses may allow the two pallets to be secured together, for example by allowing the feet of one pallet 2012 to 'clip' into the recess in the opposing pallet 2010. The recesses in the pallet platform may be provided with deformable teeth 2014 or prongs that fit tightly around the feet of the upper pallet to hold the pallets together. In some embodiments, the feet may also be provided with corresponding teeth to grip the edges of the recess in the platform.

Alternatively, a separate 'clip' mechanism may be provided to secure the two pallets together into the double pallet configuration. Inserting the feet of one pallet into recesses in the opposing pallet also allows the height of a double-sided pallet to be roughly equal to the height of a single-sided pallet.

Preferably, the two pallet elements may be joined without an adhesive or fixing mechanism simply by applying pressure to the elements. The pressure necessary to join the pallet elements is preferably not so large that a machine is required to join the elements. For example, the pressure required is preferably similar to the pressure exerted by a person standing on the pallet (for example 500-1000N) or the impact provided by a hammer (for example a hammer of around 2kg may provide an impact of around 10Ns), however, the pallets may be designed to be joined using a smaller or a larger required pressure.

In an alternative embodiment, the feet of the pallet may be formed with prongs 2410 and corresponding slots 2412, as illustrated schematically in Fig. 24. On rotation of

one of the pallets, the prongs of one set of feet may engage with the corresponding slots of the other set of feet to form a double-sided pallet.

5 Embodiments of the pallet are preferably manufactured using the rotational moulding techniques described herein. Each pallet may be moulded individually but, preferably, a large number of pallets are moulded in a single rotational moulding operation.

10 Fig. 21 illustrates how a plurality of pallets 2110 may be moulded within a single moulding operation around the walls of a larger mould 2112. If necessary, pallets moulded in this way may be cut or punched out of the sheet of moulded pallets on release from the mould.

In an alternative embodiment, the mould may comprise a plurality of layers of pallet moulds, for example in a cubic or cuboid arrangement.

15

Preferably, the pallets are moulded using the rocking and rotating methods described in more detail herein.

20 Fig. 22 illustrates a portion of a mould which may be used to form pallets such as those illustrated in Figs. 17 to 20. The portion of the mould that is illustrated may be used to form the underside of the platform of the pallet, including the pallet feet, which can be seen as recesses in the mould 2210, and the recesses into which the feet of other inverted pallets may be inserted 2212, which can be seen as raised areas of the mould. The central raised sections of the mould 2214 may be provided to form  
25 large shallow recesses in the underside of the platform of the pallet. This may decrease the net weight of the pallet without significantly reducing the strength of the pallet.

30 Fig. 23 is a close-up view of part of the mould portion illustrated in Fig. 22. A recess for a foot of the pallet 2312 and raised portions for forming recesses in the pallet 2310 are illustrated in more detail.

Figs. 25 to 27 illustrate schematically different views of parts of a mould that may be used to form the pallets. In particular, the figures illustrate recesses 2510 to form the feet of the pallet, raised sections to form hollows 2512 within the feet and further raised sections 2514 to form shallow hollows in the platform, as described above.

5

As described in more detail herein, the pallet is preferably formed from a filled plastics material. At least a portion of the pallet, for example the pallet platform, may have an outer skin layer and an inner layer of a different composition. In one embodiment, the inner layer may be a foamed layer.

10

In one method of manufacture, pallets and containers may be manufactured in the same location using similar rotational moulding techniques as described herein. This may allow the pallets to be distributed for use within the containers. That is, a batch of pallets may be stacked, preferably nested, within a container and the container, together with the pallets, may be shipped to the required destination. This may be particularly advantageous since a user who requires a container is also likely to require pallets to stack goods within the container.

15

A method of manufacturing an embodiment of a container, pallets, cable reels, and other similar apparatus using rotational moulding techniques will now be described in more detail. This method is applicable to a wide range of products manufactured from plastics based materials and is not limited to the storage and transportation products described.

20

Conventional rotational moulding techniques are well known in the art. A feedstock is inserted into a preformed mould. The mould is then placed into an oven to melt the feedstock and the mould is rotated and tilted to cover the interior of the mould with a layer of the melted feedstock. The rotation of the mould may be performed using a spider having a plurality of legs, for example three legs, wherein a mould may be attached to and rotated relative to each leg of the spider and wherein the spider as a whole may also be rotated. Once this stage of the process is complete, the mould is then cooled, for example by removing it from the oven or by cooling the oven itself. During the cooling process, the mould continues to be rotated to ensure it remains

25  
30



evenly coated. Once cooled, the product may be removed from the mould for further processing.

For some applications, rotational moulding may be preferable to, for example, blow  
5 moulding or injection moulding, since the process introduces fewer stresses into the  
moulded product. In addition, components can be incorporated into the rotationally  
moulded product by positioning the components within the mould before the  
rotational moulding process begins. The prior art rotational moulding process,  
however, is slow and inefficient. Each moulding cycle requires a large amount of time  
10 to allow the oven to heat to the required temperature and to cool the mould at the end  
of the heating process. In addition, a large amount of energy is wasted in the heating  
and cooling cycle.

To alleviate some of the problems with conventional rotational moulding techniques  
15 discussed above a new rotational moulding technique and apparatus will now be  
described with reference to Fig. 1. The apparatus and methods described herein may  
be used to form all of the products described herein.

As in a conventional rotational moulding technique, the product is preferably formed  
20 within a mould 110. The inner surface of the mould is preferably formed with a shape  
corresponding to the required outer shape of the product, for example a container with  
a corrugated outer surface may be formed using a mould with a corresponding  
corrugated inner surface. In the present embodiment, the apparatus further includes an  
inner mould portion 112, or liner, placed within the outer mould portion 110, hence  
25 the product 114 is formed between the surfaces of the inner mould portion 112 and the  
outer mould portion 110.

In a preferred embodiment, the apparatus described herein is formed substantially in a  
single moulding operation, for example, the main body of the freight container may be  
30 formed in a single piece. Hence a large mould may be required, for example to  
encompass a container that meets the 40' high-cube specification. Large moulds may  
also be used to mould a plurality of products in a single moulding operation, for  
example a number of pallets may be moulded in a single mould. In the case of a



container, the container is formed around the outer surface of the inner mould portion 112. In the case of smaller products, such as a pallet, each product is formed between the surfaces of the inner 112 and outer 110 moulds.

5 To mould the product, a predetermined amount of the feedstock is placed within the apparatus between the inner and the outer mould portions and the mould is heated. The walls of the mould may be heated by any suitable heating means, for example using heating plates embedded in the walls of the mould but, in the present embodiment, the mould is heated by applying direct heating means 118, for example a  
10 plurality of gas burners, to the exterior of the mould walls. The mould may then be rotated through the gas burners 118 to heat the mould walls evenly and hence obtain an even thickness of the plastics-based material over the walls of the mould. In the present embodiment, the gas burners are coupled to a bar 116 and the bar is maintained at a constant distance from the mould walls by spring elements. This may  
15 ensure that the walls of the mould are heated evenly and to a constant temperature. The compositions described herein may be softened at a temperature of about 160° and may be melted at a temperature of about 220°.

The inner surface of the inner mould portion 112, or liner, is preferably further heated  
20 by a gas burner within the liner 120. Hence both the outer mould portion 110 and the liner 112 are evenly heated. This may enable an even distribution of plastics-based feedstock within the mould.

Probes 122 within the mould monitor the temperature inside the mould to determine  
25 when the feedstock has melted. Probes 112 may be positioned within the inner mould portion 112 of the apparatus and may monitor the air temperature within the inner mould portion.

A heat shield may further be provided to reflect heat from the gas burners onto the  
30 surface of the apparatus.

Figs. 2a, 2b, Fig. 3 and Fig. 4 illustrate further embodiments of apparatus for performing the method described herein. The mould 210 is supported on a carriage

212, which may enable the mould to be rocked and rotated, or spun, to coat the whole of the mould, between the outer mould portion and the inner mould portion, with a layer of the feedstock. It has been found that the surfaces of the mould may be coated sufficiently using only a low rate of rotation and only a small angle of tilting. For example, a rotation rate of about 4 rotations per minute and a tilt cycle rate of about 2 cycles per minute with a maximum angle of inclination of  $15^\circ$  may be sufficient to distribute the melted feedstock over the surfaces of the mould.

Once the interior surface of the mould has been coated, the gas burners may be turned off and the mould may be cooled, for example by rotating the mould through a stream or jet of water or of air. Alternatively, the mould may be cooled using a cooling jacket, for example a water-cooled or oil-cooled jacket.

If a layered product is required, however, it is not necessary to cool the coated mould. Instead, further feedstock may be introduced to the mould, for example a feedstock having a different composition may be introduced, and the mould may continue to be rotated until the second layer of feedstock has covered the inner surface of the first, outer layer. Further layers of material may continue to be added in this way to build up the product.

If there is no inner mould portion in the apparatus, the feedstocks for the further layers may simply be added to the inside of the mould, however, if the first outer layer of the product is formed over the surfaces of an outer and an inner mould portion, it will be appreciated that any further feedstock for a further, inner layer of the product must be inserted within the skin or shell of the outer layer. In the present embodiment, this is achieved by providing areas of the outer mould portion that are covered in a coating to which the melted feedstock does not adhere, as shown at 124 in Fig. 1. For example, for a polyethylene composition, areas on the inner surface of the outer mould portion may be covered with a Teflon (RTM) coating. The non-stick areas of the mould may be removable from the mould leaving apertures 124, preferably small apertures, through the outer mould portion and through the skin formed by the first feedstock, to the interior of the skin formed by the first feedstock. A further feedstock may then be added to the interior of the skin formed by the first feedstock to provide an inner layer

for the product. For a container, non-stick areas are preferably provided at diametrically opposite corners of the container mould.

5 It will be appreciated that it is advantageous to insert the second feedstock into the interior skin of the first feedstock as quickly as possible after the first feedstock has coated the surfaces of the mould. This may allow a better bond to be formed between the two layers and may reduce the cycle time for manufacturing the product. Methods and apparatus for fast and efficient insertion of the second feedstock will be described in more detail below.

10

As outlined above, it has been found that it is not necessary to cool each layer of the product within the mould before adding a further layer. Rather, simply adding the next layer allows a secure bond to be formed between the layers of the product without significant mixing or blending occurring between the layers.

15

Once all of the required layers have been added, the mould and the product within the mould may be cooled, preferably by rotating the mould through a jet or stream of water. To decrease the time for the cooling part of the cycle, the cooling means may be applied both to the exterior surface of the outer mould portion and to the interior  
20 surface of the inner mould portion.

The methods described above may allow a product, such as a container, or a batch of products, such as a batch of pallets, to be manufactured in a cycle time of about 20 minutes.

25

Other methods of moulding or forming the products described herein, such as the container, may be used and the products may be moulded in several sections, which may subsequently be joined together. For example, the doors of the container may be moulded separately and then may be joined to the main part of the container. In the  
30 present embodiment, the main body of the container and the doors of the container may each be provided with corresponding parts that may be assembled into a piano-type hinge. The two parts of the hinge may be manufactured as part of the door and

the main body and the door may be coupled to the main body of the container by inserting a rod through corresponding sections of the hinges.

An embodiment of the container itself will now be described in more detail with reference to Figs. 5 and 6. According to one embodiment, the container is formed as a 40' high-cube container with each wall comprising an outer skin layer 510 and an inner layer 512.

Each layer of the walls of the container comprises a filled plastics-based material containing plastic, a filler and a unifier material, but the relative amounts of the components of the material vary between layers. The outer skin layer 510 preferably comprises a larger proportion of a high-quality plastics material, such as polyethylene, for example the plastics material may comprise about 60% by weight of the composition, and a smaller proportion of a filler, for example about 40% by weight of the composition. The inner layer 512 preferably contains a relatively high proportion of the filler material, for example about 60% by weight and the foam layer is preferably highly foamed, for example 50% foamed. The foaming ingredient may be, for example, Sodium Bicarbonate. The total thickness of the container walls may be about 60mm, but this may be varied depending on the requirements of the container. In one embodiment, the thickness of the outer skin layer may be about 5-8mm and the thickness of the inner layer may be about 40-60mm. In one embodiment, the walls of the container may be only 30mm thick.

In an alternative embodiment, the inner layer 512 may be formed with a low proportion of filler material or may include no filler material. For example, the inner layer 512 may comprise a plastics material and a foaming agent. In one embodiment, the outer skin layer 510 may comprise a high proportion of filler, for example about 60% by weight filler.

The filler material of the present embodiment is sand, preferably dredged sand, since this has finer particles than desert sand. Alternative filler materials may include ash, a carbonate material such as calcium carbonate, another silicate material such as ground



rock, or a salt material such as sodium chloride or an organic material, such as straw, peanut hulls, vegetable waste, miscanthus, wood flour or animal droppings.

5 The net weight of embodiments of containers as described above may be about 3000 kilograms, preferably about 2800 kilograms, although heavier or lighter containers may also be formed using the techniques described herein. The net weight of a prior art steel container is about 3800-4200 kilograms, so containers as described herein may provide a significant saving in weight, for example on a container ship on which a large number of containers may be transported.

10

Preferably, the exterior surfaces of the container are not flat surfaces but have raised sections or corrugations 514 as shown in Fig. 5. In addition, the lower surface of the container may be formed with a raised grid of bars, for example in a waffle pattern. This may provide additional strengthening to the lower surface of the container, which  
15 may support the majority of the weight of the contents of the container and may further be required to support the weight of loading machinery, such as a fork-lift truck, which may be driven inside the container to load the contents.

20 An embodiment of a model of a 40 foot container formed according to the methods described herein is illustrated in Fig. 6.

Non-plastic components or pre-formed components may be incorporated into the container during its manufacture. For example, a steel frame may be incorporated into the container by placing the steel frame within the mould and forming the plastic  
25 layers of the container around the steel frame. Including a steel frame in the container may increase the strength of the container and may allow weight to be distributed evenly throughout the container structure. It is noted, however, that it has been found that it is not necessary to include a steel frame in embodiments of the container described herein to enable the container to meet the requirements of the industry  
30 standards.

Reinforcing eyelets may further be provided in some embodiments of the container, preferably in the four corners of the container, by over-moulding the eyelets into the



plastic composition during the moulding process. An embodiment of a reinforcing eyelet is illustrated in Fig. 7. Fig. 8 illustrates one embodiment of an eyelet incorporated into a container manufactured according to the methods and apparatus described herein. The reinforcing eyelets may be used to connect the container to lifting apparatus, such as lifting gantries, and may provide additional strength to the container at these points.

A door fastening or locking mechanism may further be incorporated into the container. Preferably, the door mechanism may be moulded so that it is within the container. The door mechanism preferably comprises a prior art door mechanism as used for the prior art steel containers.

Preferably, the cycle time for manufacturing a container body as described herein, with an outer skin layer and an inner layer, is about 20mins. The container is preferably heated at a carefully controlled rate to ensure that the container walls are of an even thickness and is preferably further cooled at a carefully controlled rate to ensure that the container walls do not become distorted.

In a further embodiment of the container described herein, a fibrous material may be incorporated into the container to further bind the composition and strengthen the container, particularly when it is subjected to tensional or bending forces.

A further product which may be manufactured using the methods and apparatus described herein is a pallet. An embodiment of a pallet is illustrated herein in Figs. 9a and 9b. Traditionally, pallets are manufactured from wood, but a pallet manufactured according to the methods described herein may provide a number of advantages over a prior art wooden pallet. In particular, the usable life of a pallet described herein may be greater than that of a wooden pallet and the present pallets may be more environmentally sustainable than wooden pallets. Freight distributors often do not use wooden pallets more than once to ensure that each pallet used is in good condition for transporting the goods. In addition, it is often not economical to repair broken wooden pallets, since the cost of repair often exceeds the cost of a new pallet.

Figs. 9a and 9b illustrate one embodiment of a pallet, although it will be appreciated that a wide variety of shapes and sizes of pallets may be formed using the methods described herein. The pallet illustrated in Figs. 9a and 9b comprises a platform 910, on which the goods to be transported may be placed or stacked, and a plurality of feet 912. In this embodiment, the pallet comprises nine feet spaced in a regular pattern over the bottom surface of the pallet. The pallet illustrated is a rectangular two-way access pallet, but rectangular or square pallets may be formed and may be designed as four-way access pallets to enable machinery, such as a fork-lift truck, to access and move the pallet from any one of four directions.

10

Optional bracing members 914 may be provided between some or all of the feet of the pallet as shown in Fig. 9b, however the bracing members are not a necessary feature of the pallet.

15 The feet of the pallet may contain recesses or hollows, so may not be whole. This may reduce the weight of the pallet.

The pallet is preferably manufactured using a rotational moulding technique. Preferably, a plurality, or batch, of pallets is formed in a single moulding operation.

20 The inner surface of the outer mould portion of the apparatus may be formed with a plurality of indentations, corresponding to the feet of the pallet, and the surface of the inner mould portion of the apparatus may be formed as a flat surface, to provide a pallet with a flat pallet surface to be formed. Alternatively, indentations or texture may be provided on the surface of the inner mould portion to allow a pallet with an  
25 uneven or textured platform surface to be formed.

A further embodiment of a pallet is illustrated in Fig. 10. In a preferred embodiment, the pallet comprises an outer skin surface 1010 comprising about 60% by weight of a plastics material, such as polyethylene, preferably HDPE, about 40% by weight of a  
30 filler material, such as sand or calcium carbonate, and a small amount of a unifier material. Once the outer skin has been formed in the moulding apparatus, a second foam composition 1012 may be inserted into the outer skin using the method described above, and the inner foam material 1012 may be distributed throughout the

outer skin 1010. The foam composition may be introduced as a solid material but may start to foam on the application of heat to the material. In the present embodiment, the foamed material may be 50% foamed.

5 In one embodiment, the pallet may comprise a single, solid plastics-based filled material and may not include a foam layer. However, including a foam layer may enable the finished pallet to be lighter and may add strength to the pallet when compared to a solid pallet manufactured with indentations to reduce the amount of plastics-based material used.

10

Further products may be manufactured using the methods and compositions described herein. For example, fencing or screening material may be provided in sheet form, with or without a foam layer. Building materials, for example panels that may be used as internal or external walls or components that may be used for decking, may further  
15 be provided. Similarly, the methods and compositions described may be used to provide ship-building materials, such as a hull for a ship, boat or tanker.

In some embodiments, a plurality of layers may be provided in a product and each layer may comprise a different composition. For example, the upper and lower  
20 surfaces of the outer skin layer described herein may be formed separately in different moulding cycles and may be formed from different compositions. In some embodiments, non-plastics based layers, for example metals-based layers, may be incorporated into the product.

25 The methods described above may be implemented in a moulding plant and an embodiment of a plant is illustrated in Figs. 11 and 12. However, it will be appreciated that a wide variety of manufacturing plants may be used and the plants may be adapted depending on the product being manufactured. The plastics composition feedstocks may be mixed within the plant, or may be mixed and  
30 delivered to the plant as raw materials, for example in pellet form. Preferably, the feedstock may be formed by mixing the components and forming pellets from the mixed components. Preferably, the unifier may be mixed with the filler before the polymer is added to the mixture.

The plant illustrated in Fig. 11 includes a central container area 1110 comprising a plurality of containers 1112, each containing a preformed feedstock. A plurality of mobile feedstock machines 1114 obtain a predetermined quantity of feedstock from the central containers 1112 and deliver them to each of a plurality of moulding apparatus 1116.

As illustrated in Figs. 12 and 13, the feedstock machines 1210 insert the feedstock into the moulding apparatus 1212. It has been found that it is advantageous to tilt the moulding apparatus 1212 to enable the feedstock to be delivered efficiently to the moulding apparatus 1212. The feedstock machines 1210 are preferably provided with telescopic arms 1214 and telescopic delivery buckets 1216 for delivering the feedstock to the moulding apparatus 1212 along the whole length of the apparatus. This may be particularly advantageous when inserting the second feedstock into the moulding apparatus 1212, since inserting the feedstock along the whole length of the apparatus may enable the feedstock to be inserted more quickly into the apparatus, while the first feedstock is relatively fluid. The telescopic delivery bucket 1216 preferably extends to a length of about 12m, so it may extend the whole length of a container mould, and preferably holds a predetermined amount of feedstock. Preferably, the bucket 1216 is divided into a plurality of sections, each of which holds a predetermined amount of feedstock.

Properties of compositions described herein will now be outlined in more detail. The description below is provided by way of example only and the compositions and parameters provided are not intended to be limiting. The mouldings described were carried out under the following moulding conditions:

Oven temperature = 300 C

Rotation ratio  $\approx$  4:1

Cooling medium = Forced air

Sheet steel test mould

All cycle times are taken from the same start and end point to allow for easier comparisons of the various stages in the internal air temperature traces. For each moulding carried out, Polyethylene was mixed with sand in a 50:50 mixture by mass. To this mixture, different levels of unifier were added from 1 % by weight to 10% by weight.

The polyethylene grade used was a rotomoulding grade, RG 7243 produced by Borealis in Norway, this material is a standard LLDPE grade with a density of  $924\text{kg/m}^3$  and a MFI of 4.5.

10

	Grade	Cycle Time (min)
	T963	20.17
	T964	22.35
	T965	21.7
15	T966	22.77
	T967	22.05
	T968	22.87
	T969	22.06
	T970	22.07
20	T971	23.23
	T972	22.94
	Polyethylene	33.23

It can be seen from the data above that the cycle time of each filled moulding is not affected by the addition of different levels of unifier but there is a substantial difference between the filled and the polyethylene mouldings. It is assumed that difference is due to the filled mouldings containing half the amount of PE as the polyethylene mouldings.

Standard tensile test specimens were produced from the filled mouldings using a die. The specimens were tested on an Instron 4411 tensile testing machine at a crosshead speed of 20 mm/min (as per standard ASTM 638). The data provided below shows the



mechanical properties of each of the grades tested. A standard unmodified polyethylene grade is also added as a comparison.

	Grade	Stress at Break (MPa)	Strain at Break (%)	Modulus (MPa)
5	T963	1.95	21.9	172.0
	T964	2.13	22.4	141.6
	T965	1.65	17.7	131.0
	T966	1.68	13.3	153.0
	T967	2.10	21.5	142.9
10	T968	1.16	8.2	121.6
	T969	2.52	19.7	108.7
	T970	2.24	20.5	113.4
	T971	1.17	11.3	128.5
	T972	1.05	9.6	101.2
15	Standard	--	--	223

There is a lot of scatter in the values of the mechanical properties determined for all the grades tested. However, the general trend shows a decrease in modulus as the percentage of unifier is increased.

20

Figs. 14, 15 and 16 illustrate graphically the properties of the filled compared to polyethylene as described above.

25

As will be appreciated by one skilled in the art, aspects of the invention may be provided independently and features of one aspect may be applied to other aspects. It will also be appreciated that the methods described herein may be used to manufacture a wide range of products and the invention is not limited to the products described herein.

Claims:

1. A pallet element comprising a platform having an upper surface and a lower surface and a plurality of feet depending from the lower surface of the platform and wherein:  
5 a single pallet element provides a single-sided pallet having feet of a height sufficient to allow lifting by a forklift truck;  
a first said pallet element is arranged to couple to a second said pallet element to provide a double-sided pallet having a total height less than double the  
10 height of a single pallet element.
2. A pallet element according to Claim 1 wherein the first and the second pallet elements couple to provide a double-sided pallet wherein the feet of both the first and the second pallet are arranged between the platforms of the pallet  
15 elements.
3. A pallet element according to Claim 1 or 2 wherein the pallet elements are arranged to couple on presenting opposed elements appropriately located without further fixings or adhesives.  
20
4. A pallet element according to any preceding claim wherein the height of single pallet element is substantially equal to the height of a standard pallet.
5. A pallet element according to any preceding claim wherein the height of a  
25 single pallet element is at least around 100mm.
6. A pallet element according to any preceding claim wherein in a double-sided pallet, the feet of the first pallet element interleave at least partially with the feet of the second pallet element.  
30
7. A pallet element according to any preceding claim wherein the height of a double-sided pallet is substantially equal to the height of a single-sided pallet.

8. A pallet element according to any preceding claim wherein the height of a double-sided pallet is substantially equal to the height of a standard pallet.

5 9. A pallet element according to any preceding claim wherein the height of a double-sided pallet is less than around 200mm.

10 10. A pallet element according to any preceding claim wherein the difference in height between a double-sided pallet and a single-sided pallet is substantially equal to the height of the platform of a pallet element.

11. A pallet element according to any preceding claim wherein the difference in height between a double-sided pallet and a single-sided pallet is less than the height of the platform of a pallet element.

15 12. A pallet element according to any preceding claim wherein the height of the feet supporting the platform of a single-sided pallet is substantially equal to the spacing between platforms of a double-sided pallet.

20 13. A pallet element according to any preceding claim wherein the first pallet element is coupled to the second pallet element by inserting the feet of at least one pallet element into recesses formed in the lower surface of the platform of the other pallet element.

25 14. A pallet element according to any preceding claim wherein the recesses in the lower surface of the platform comprise deformable teeth, wherein the deformable teeth latch around the feet of the opposing pallet element to retain the feet in the recesses.

30 15. A pallet element according to any of Claims 1 to 12 wherein the feet of each pallet element comprise foot elements, the foot elements of each foot being arranged to interleave with corresponding foot elements in the opposing foot.

16. A pallet element according to any preceding claim wherein at least one foot is arranged substantially at each corner of the platform.

5 17. A pallet element according to any preceding claim wherein at least one foot is arranged substantially at the centre of the platform.

18. A pallet element according to any preceding claim wherein at least one foot is arranged substantially at the centre of each edge of the platform.

10 19. A pallet element according to any preceding claim wherein the feet of the pallet elements are arranged so that, on rotation of one pallet element about an axis through the plane of the platform of the pallet, a male configuration of feet on one pallet element mates with a female configuration of feet on the opposing pallet element.

15 20. A pallet element according to any preceding claim wherein at least some of the feet of the pallet are arranged on the platform rotationally asymmetrically about at least one axis of rotation passing through the centre of the plane of the platform of the pallet and parallel to an edge of the pallet.

20 21. A pallet element according to Claim 19 or 20 wherein one male configuration of feet comprises a single foot and a corresponding female configuration of feet comprises two feet separated by a gap, wherein the gap is sized to accommodate a single foot.

25 22. A pallet element according to any preceding claim wherein the pallet element is substantially rectangular.

30 23. A pallet element according to any preceding claim wherein, when one pallet element is rotated in an axis in the plane of the pallet platform and perpendicular to the elongate axis of the pallet platform, the feet of the pallet element interleave with the feet of a second pallet element.

24. A pallet element according to any preceding claim wherein, when the first pallet is rotated, the feet of the first pallet are offset relative to the feet of the second pallet.

5 25. A pallet element according to any of Claims 19 to 24 wherein a male configuration of feet comprises an odd number of feet and a female configuration of feet comprises an even number of feet.

10 26. A pallet element according to any of Claims 19 to 25 wherein the feet in the male configuration and the feet in the female configuration are mutually offset when a first pallet element is rotated and positioned over a second pallet element so that the platforms are aligned.

15 27. A pallet element according to any of Claims 19 to 26 wherein feet in the corners of the pallet comprise male or female configurations of feet and feet in the along the centre lines of the pallet are mutually offset from the centre.

20 28. A pallet element according to any preceding claim wherein the pallet elements are rotationally moulded.

29. A pallet element according to any preceding claim wherein each pallet element is rotationally moulded substantially in one piece.

25 30. A pallet element according to any preceding claim wherein the pallet elements are manufactured substantially from a filled plastics material.

31. A pallet element according to any preceding claim wherein the filler comprises a mineral filler material.

30 32. A pallet element according to any preceding claim wherein the feet of each pallet element are formed integrally with the platform of the pallet element.



33. A pallet element according to any preceding claim wherein the feet are tapered from a maximum width at the platform of the pallet element.

5 34. A pallet element according to Claim 33 wherein at least one side of at least one tapered foot of the pallet is concave.

35. A pallet element according to any preceding claim wherein recesses are provided in the upper surface of the platform of the pallet.

10 36. A pallet element according to Claim 35 wherein the recesses in the upper surface correspond to the position of the feet of a pallet element.

37. A pallet element according to any preceding claim wherein at least one foot is hollow.

15

38. A pallet element according to any of Claims 35 to 37 wherein the recesses in the upper surface extend through the platform from the upper surface of the pallet element into the feet.

20

39. A pallet element according to any preceding claim wherein pallet elements form a nested configuration when stacked on top of each other in the same orientation.

25

40. A pallet element according to any preceding claim wherein, in a nested configuration, the feet of one pallet element are inserted into recesses in the corresponding feet of a second pallet element.

30

41. A pallet element according to any preceding claim wherein the feet are arranged to enable the blades of a forklift truck to engage the pallet from any one of four directions.

42. A pallet element according to any preceding claim wherein at least a portion of the pallet element comprises an outer skin layer.

43. A pallet element according to Claim 42 wherein at least a portion of the pallet element comprises an inner layer having a different composition to the outer skin layer.

5

44. A pallet element according to Claim 43 wherein the inner layer comprises a foaming agent.

10

45. A pallet element according to any preceding claim wherein the pallet element further comprises a remotely readable tag, preferably an RFID tag.

46. A pallet element according to any preceding claim wherein the platform of the pallet element comprises a substantially continuous surface.

15

47. A pallet element according to any preceding claim wherein the platform of the pallet element comprises a textured surface.

20

48. A method of assembling a double-sided pallet using two pallet elements, each pallet element comprising a platform and a plurality of feet depending from the platform, the method comprising:

rotating the first pallet element about an axis in the plane of the pallet platform;

arranging the second pallet element on top of the first pallet element so that the feet of both of the pallet elements lie between the platforms of the pallet

25

elements and the feet of the pallet elements are interleaved;

coupling the second pallet element to the first pallet element.

30

49. A method according to Claim 48 wherein step of coupling comprises applying pressure to the pallet elements.

50. A method according to Claim 49 wherein applying pressure comprises applying a force of less than around 1000N, preferably less than around 500N, or applying an impact from a hammer of less than around 10Ns.

51. A method according to any of Claims 48 to 50 wherein coupling comprises coupling the pallet elements without adhesives or fixings.

5 52. A method of manufacturing a plurality of pallets comprising:  
inserting a feedstock comprising a filled plastics material into a mould;  
rotating and heating the mould to rotationally mould a plurality of pallets;  
releasing the plurality of pallets from the mould  
separating the moulded plurality of pallets into single pallets.

10

53. A method according to Claim 52 further comprising inserting a second feedstock into the mould to form an inner layer within the pallet.

15

54. A method according to Claim 53 wherein the second feedstock includes a foaming agent to form a foamed inner layer.

55. A method according to any of Claims 52 to 54 wherein separating the moulded plurality of pallets comprises punching or cutting the pallets out of a sheet of moulded pallets.

20

56. A method of distributing pallets comprising arranging layers of pallets in a nested configuration in a container, shipping the container to a predetermined destination, removing the pallets from the container.

25

57. A method according to Claim 56 wherein the pallets comprise pallet elements according to the aspect described above or any of its preferred features.

58. A method according to Claim 56 or 57 wherein the pallets and the container are rotationally moulded.

30

59. A method according to any of Claims 56 to 58 wherein the layers of pallets are provided in sheets and the method further comprises cutting the sheets of pallets into individual pallets.

60. A rotationally-moulded load-carrying apparatus for carrying a load of at least 50 kilograms, wherein the apparatus is manufactured substantially from a filled plastics material comprising:

at least 10% by weight of a polymer;

at least 10% by weight of a mineral filler material.

61. Apparatus according to Claim 60 wherein the mineral filler material comprises a silicate material, preferably sand.

62. Apparatus according to Claim 60 wherein the mineral filler material comprises a carbonate material, preferably calcium carbonate.

63. Apparatus according to Claim 60, 61 or 62 wherein the polymer comprises polyethylene, preferably wherein the polymer comprises High Density Polyethylene (HDPE).

64. Apparatus according to any of Claims 60 to 63 wherein the material comprises at least 25% by weight filler.

65. Apparatus according to any of Claims 60 to 64 wherein the material comprises at least 25% by weight polymer.

66. Apparatus according to any of Claims 60 to 65 wherein the material comprises from about 30% to about 70% by weight polymer and from about 70% to about 30% by weight filler.

67. Apparatus according to any of Claims 60 to 66 wherein the filled plastics material further comprises a unifier.

68. Apparatus according to Claim 67 wherein the filled plastics material comprises at least about 0.1% by weight unifier.

69. Apparatus according to Claim 67 or 68 wherein the filled plastics material comprises less than about 10% by weight unifier.

5 70. Apparatus according to any of Claims 67 to 69 wherein the filled plastics material comprises at least about 0.25% by weight unifier.

71. Apparatus according to any of Claims 67 to 70 wherein the filled plastics material comprises less than about 5% by weight unifier.

10 72. Apparatus according to any of Claims 67 to 71 wherein the unifier is pre-mixed with the filler.

73. Apparatus according to Claim 67 wherein the unifier comprises an internal lubricant.

15 74. Apparatus according to Claim 73 wherein the internal lubricant comprises a fatty acid amide.

20 75. Apparatus according to Claim 74 wherein the internal lubricant comprises a straight or branched C12-C24 fatty acid amide.

76. Apparatus according to any of Claims 73 to 75 wherein the internal lubricant comprises steramide.

25 77. Apparatus according to any of Claims 73 to 76 wherein the unifier further comprises an external lubricant, preferably wherein the external lubricant comprises a stearate.

30 78. Apparatus according to any of Claims 73 to 77 wherein the unifier comprises less than 20% by weight internal lubricant.

79. Apparatus according to any of Claims 73 to 78 wherein the unifier comprises about 10% by weight internal lubricant.



80. Apparatus according to any of Claims 60 to 79 wherein the filler comprises at least one of:  
a silicate material, preferably sand;  
5 ash;  
a carbonate material, preferably calcium carbonate;  
a salt, preferably sodium chloride.
- 10 81. Apparatus according to any of Claims 60 to 80 wherein the apparatus is rotationally moulded substantially in one piece.
82. Apparatus according to any of Claims 60 to 81 wherein the filler comprises a light-coloured material.
- 15 83. Apparatus according to any of Claims 60 to 82 wherein the apparatus comprises a pallet.
84. Apparatus according to Claim 83 wherein the pallet is moulded substantially in one piece.
- 20 85. Apparatus according to Claim 83 or 84 wherein the pallet comprises a platform and a plurality of feet depending from the platform.
- 25 86. Apparatus according to Claim 85 wherein the feet of the pallet are regularly spaced over the lower surface of the platform.
87. Apparatus according to Claim 85 or 86 wherein the feet are arranged to enable lifting equipment to engage the pallet from any one of four directions.
- 30 88. Apparatus according to any of Claims 85 to 87 wherein at least one foot is arranged substantially at each corner of the platform of the pallet.

89. Apparatus according to any of Claims 85 to 88 wherein at least one foot is arranged substantially at the centre of the platform of the pallet.

5 90. Apparatus according to any of Claims 85 to 89 wherein at least one foot is arranged substantially at the centre of each edge of the platform of the pallet.

91. Apparatus according to any of Claims 85 to 90 wherein the feet of the pallet are moulded integrally with the platform.

10 92. Apparatus according to any of Claims 85 to 91 wherein each foot has a recess in the lower surface of the foot.

93. Apparatus according to any of Claims 83 to 92 wherein the pallet comprises an outer skin layer having an upper surface and a lower surface.

15 94. Apparatus according to Claim 93 wherein the upper and lower surfaces of the outer skin layer are arranged to abut each other over at least a portion of the pallet surface.

20 95. Apparatus according to Claim 93 or 94 wherein the pallet further comprises an inner layer having a different composition to the outer skin layer.

96. Apparatus according to Claim 95 wherein the inner layer comprises a foaming agent.

25 97. Apparatus according to Claim 95 or 96 wherein the inner layer comprises at least 40% by weight of a filler.

30 98. Apparatus according to any of Claims 83 to 97 wherein the pallet has a length of at least 800mm.

99. Apparatus according to any of Claims 60 to 98 wherein the apparatus comprises a plurality of layers.

100. Apparatus according to Claim 99 wherein the composition of the filled plastics material differs between the layers.

5 101. Apparatus according to Claim 99 or 100 wherein the composition of a first layer of the apparatus is optimised to provide an outer skin layer.

102. Apparatus according to Claim 101 wherein the outer skin layer comprises more than about 50% by weight polymer.

10

103. Apparatus according to Claim 101 or 102 wherein the outer skin layer comprises about 60% by weight polymer.

15

104. Apparatus according to any of Claims 99 to 103 wherein the composition of a second layer of the apparatus is optimised to provide an inner layer.

105. Apparatus according to Claim 104 wherein the inner layer comprises a polymer.

20

106. Apparatus according to Claim 104 or 105 wherein the inner layer comprises a polymer and a filler.

25

107. Apparatus according to Claim 106 wherein the inner layer comprises more than about 30% by weight filler.

108. Apparatus according to Claim 106 or 107 wherein the inner layer comprises more than about 50% by weight filler.

30

109. Apparatus according to any of Claims 106 to 108 wherein the inner layer comprises about 60% by weight filler.

110. Apparatus according to any of Claims 106 to 109 wherein the inner layer comprises a greater amount of filler by weight than the outer layer.

5 111. Apparatus according to any of Claims 106 to 110 wherein the inner layer comprises a foaming agent, preferably wherein the foam layer is about 50% foamed.

112. Apparatus according to any of Claims 60 to 111 wherein the filled plastics material further comprises a pigment.

10 113. Apparatus according to any of Claims 60 to 112 wherein the apparatus incorporates a remotely readable ID tag, preferably an RFID tag.

15 114. Apparatus according to Claim 113 wherein the ID tag is moulded into the surface of the apparatus.

20 115. A method of manufacturing apparatus for storage or transportation of loads greater than about 50 kilograms, the method comprising rotationally moulding the apparatus from a filled plastics material comprising a polymer, a filler and a unifier.

25 116. A method of rotationally moulding a product from a filled plastics material comprising:  
providing a mould for the product defining a void corresponding to at least a portion of the required shape of the product;  
loading a first feedstock having a first composition comprising a polymer and at least 10% by weight of a mineral filler into the mould;  
heating the mould;  
rotating and/or rocking the mould about at least two axes to coat the internal  
30 walls of the mould with a layer of the first feedstock;  
cooling the mould;  
releasing the product from the mould.

117. A method according to Claim 116 further comprising providing heating means adjacent to the walls of the mould and heating the mould using the heating means.

5 118. A method according to Claim 116 or 117 further comprising providing cooling means adjacent to the walls of the mould and cooling the mould using the cooling means.

10 119. A method according to any of Claims 116 to 118 wherein the heating means comprises a plurality of burners.

120. A method according to any of Claims 118 to 119 wherein the cooling means comprises at least one supply of water.

15 121. A method according to any of Claims 116 to 120 wherein the mould is a generally elongate mould and wherein the method comprises rotating the mould about a first axis substantially parallel to the axis of elongation of the mould and rocking the mould about a second axis substantially orthogonal to the first axis.

20 122. A method according to any of Claims 116 to 121 wherein rocking the mould comprises rocking the mould to a maximum angle of less than about 30° from the horizontal.

25 123. A method according to any of Claims 116 to 122 wherein rocking the mould comprises rocking the mould at a rate of less than about 6 rocking cycles per minute.

30 124. A method according to any of Claims 116 to 123 wherein rotating the mould comprises rotating the mould at a rate of less than about 10 revolutions per minute.



125. A method according to any of Claims 116 to 124 wherein the mould comprises an inner mould portion and an outer mould portion, wherein the inner mould portion is positioned within the outer mould portion and wherein the first feedstock is inserted between the outer mould portion and the inner mould portion.

126. A method according to Claim 125 further comprising providing heating means within the inner mould portion.

127. A method according to any of Claims 116 to 126 further comprising maintaining the heating means at a substantially constant distance from the walls of the outer mould portion as the mould is rotated.

128. A method according to any of Claims 116 to 127 further comprising, before cooling the mould:  
loading a second feedstock having a second composition into the mould;  
rotating the mould to form a second layer of the second feedstock.

129. A method according to any of Claims 116 to 128 wherein the composition of the first layer is optimised to provide an outer skin layer.

130. A method according to Claim 128 or 129 wherein the composition of the second layer is optimised to provide an inner layer.

131. A method according to any of Claims 128 to 130 wherein the second feedstock comprises a foaming agent.

132. A method according to any of Claims 128 to 131 wherein the second feedstock comprises a higher proportion of filler than the first feedstock.

133. A method according to any of Claims 116 to 132 wherein the product comprises at least one of: a freight container, a pallet, a cable reel or a panel.

134. A method according to any of Claims 116 to 133 further comprising positioning elements of the product within the mould before the feedstock is inserted and over-moulding the elements into the product.

5 135. A method according to Claim 134 wherein the product comprises a freight container and wherein the elements comprise one or more of:  
a metal frame;  
door securing means;  
strengthening elements; or  
10 corner lifting elements.

136. A method according to any of Claims 116 to 135 wherein the product is moulded substantially in one piece.

15 137. A method according to any of Claims 116 to 136 wherein releasing the product from the outer mould portion comprises moving the walls of the outer mould portion apart and away from the moulded product.

20 138. A filled plastics material comprising:  
a polymer;  
at least 10% by weight of a mineral filler;  
a unifier comprising stearate.

25 139. A filled plastics material according to Claim 138 wherein the unifier further comprises an internal lubricant, preferably steramide.

140. A filled plastics material according to Claim 139 wherein the steramide comprises Chrodamide S Powder.

30 141. A filled plastics material according to any of Claims 138 to 140 wherein the stearate comprises Calcium Stearate.

142. A filled plastics material according to any of Claims 138 to 141 wherein the unifier comprises more than 5% by weight steramide.

143. A filled plastics material according to any of Claims 138 to 142 wherein the unifier comprises about 10% by weight steramide.

144. A filled plastics material according to any of Claims 138 to 143 wherein the unifier comprises more than 80% by weight stearate.

145. A filled plastics material according to any of Claims 138 to 144 wherein the unifier comprises about 90% by weight stearate.

146. A filled plastics material according to any of Claims 138 to 145 wherein the polymer comprises polyethylene.

147. A filled plastics material according to any of Claims 138 to 146 wherein the polymer comprises High Density Polyethylene (HDPE).

148. A filled plastics material according to any of Claims 138 to 147 wherein the filler comprises at least one of:  
a silicate material, preferably sand;  
ash;  
a carbonate material, preferably calcium carbonate;  
a salt, preferably sodium chloride.

149. A filled plastics material according to any of Claims 138 to 148 wherein the filled plastics material comprises at least 0.5% by weight unifier.

150. A filled plastics material according to any of Claims 138 to 149 wherein the filled plastics material comprises about 1% by weight unifier.

151. Apparatus for rotationally moulding, from a filled plastics material, a load-carrying apparatus for carrying a load of at least 50 kilograms, the apparatus comprising:

5 a mould defining a void corresponding to at least a portion of the required shape of the product;

means for receiving a first feedstock comprising a filled plastics material comprising a polymer and at least 10% by weight of a mineral filler;

heating means;

cooling means;

10 means for rotating and/or rocking the mould about at least two axes.

152. Apparatus according to Claim 151 wherein the heating means are provided adjacent to the walls of the mould.

15 153. Apparatus according to Claim 151 or 152 wherein the cooling means are provided adjacent to the walls of the mould.

154. Apparatus according to any of Claims 151 to 153 wherein the mould is a generally elongate mould and wherein the apparatus further comprises  
20 means for rotating the mould about a first axis substantially parallel to the axis of elongation of the mould and means for rocking the mould about a second axis substantially orthogonal to the first axis.

155. Apparatus according to any of Claims 151 to 154 wherein the mould  
25 comprises an inner mould portion and an outer mould portion, wherein the inner mould portion is positioned within the outer mould portion and wherein the first feedstock is inserted between the outer mould portion and the inner mould portion.

30 156. Apparatus according to any of Claims 151 to 155 further comprising heating means within the mould.

157. Apparatus according to any of Claims 151 to 156 further comprising means for maintaining the heating means at a substantially constant distance from the mould.

5 158. Apparatus according to any of Claims 151 to 157 wherein the mould has a length of at least 5m.

159. Apparatus according to any of Claims 151 to 158 wherein the mould has a length of at least 10m.

10 160. Apparatus according to any of Claims 151 to 159 wherein the apparatus is mounted over a pit and wherein at least one end of the mould is rocked into the pit.

15 161. Apparatus according to any of Claims 151 to 160 wherein the means for receiving the feedstock comprises a series of apertures in the outer mould portion.

20 162. Apparatus according to Claim 161 wherein the series of apertures is formed along at least one edge of the outer mould portion.

163. Apparatus according to Claim 161 or 162 to wherein the series of apertures is covered by at least one sliding gate valve.

25 164. Apparatus according to any of Claims 161 to 163 wherein the internal surface of the sliding gate valve is coated in a non-stick material.

165. Apparatus according to any of Claims 151 to 164 further comprising at least one hopper for storing the feedstock.

30 166. Apparatus according to Claim 165 wherein the hopper comprises dispensing means for dispensing a predetermined amount of the feedstock,



wherein the predetermined amount comprises the amount of feedstock required to rotationally mould at least one load-carrying apparatus.

5 167. Apparatus according to any of Claims 151 to 166 further comprising filling means for loading the mould with a predetermined amount of the feedstock.

10 168. Apparatus according to Claim 167 wherein the filling means comprises means for filling the feedstock via a series of apertures in the outer mould portion.

15 169. Apparatus according to Claim 168 wherein the means for filling the feedstock comprises at least one bucket having a series of apertures corresponding to the series of apertures in the outer mould portion.

170. Apparatus according to Claim 169 wherein the bucket comprises a telescopic bucket having an adjustable length.

20 171. Apparatus according to any of Claims 151 to 170 wherein the heating means comprises at least one burner.

172. Apparatus according to any of Claims 151 to 171 wherein the cooling means comprises a supply of water.

25 173. A unifier for promoting binding and dispersion of a mineral filler and a polymer, wherein the unifier comprises a fatty acid amide.

30 174. A unifier according to Claim 173 wherein the fatty acid amide comprises a straight or branched C12-C24 fatty acid amide.

175. A unifier according to Claim 173 or 174 wherein the unifier comprises steramide.

176. A unifier according to any of Claims 173 to 175 further comprising an external lubricant, preferably wherein the external lubricant comprises a stearate.

5 177. A unifier according to Claim 176 comprising more than 80% by weight external lubricant.

178. A unifier according to Claim 176 or 177 comprising about 90% by weight external lubricant.

10 179. A rotationally-moulded load-carrying apparatus comprising:  
at least 10% by weight HDPE;  
at least 10% by weight of a filler comprising sand;  
a unifier comprising a fatty acid amide;  
15 wherein the load-carrying apparatus comprises an inner layer and an outer layer, the layers having different compositions.

180. Apparatus according to Claim 179, wherein the apparatus comprises a pallet having a length of at least about 800mm.

20 181. Apparatus according to Claim 179 to 180 wherein the inner layer comprises a foamed layer.

25 182. Apparatus substantially as any one described herein or as illustrated in any of Figs. 1 to 27.

183. A method substantially as any one described herein with reference to any of Figs. 1 to 27.

30 184. A filled plastics material substantially any one as described herein.

185. A pallet, a mould or an assembly station substantially as any one herein described.



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FIG 7

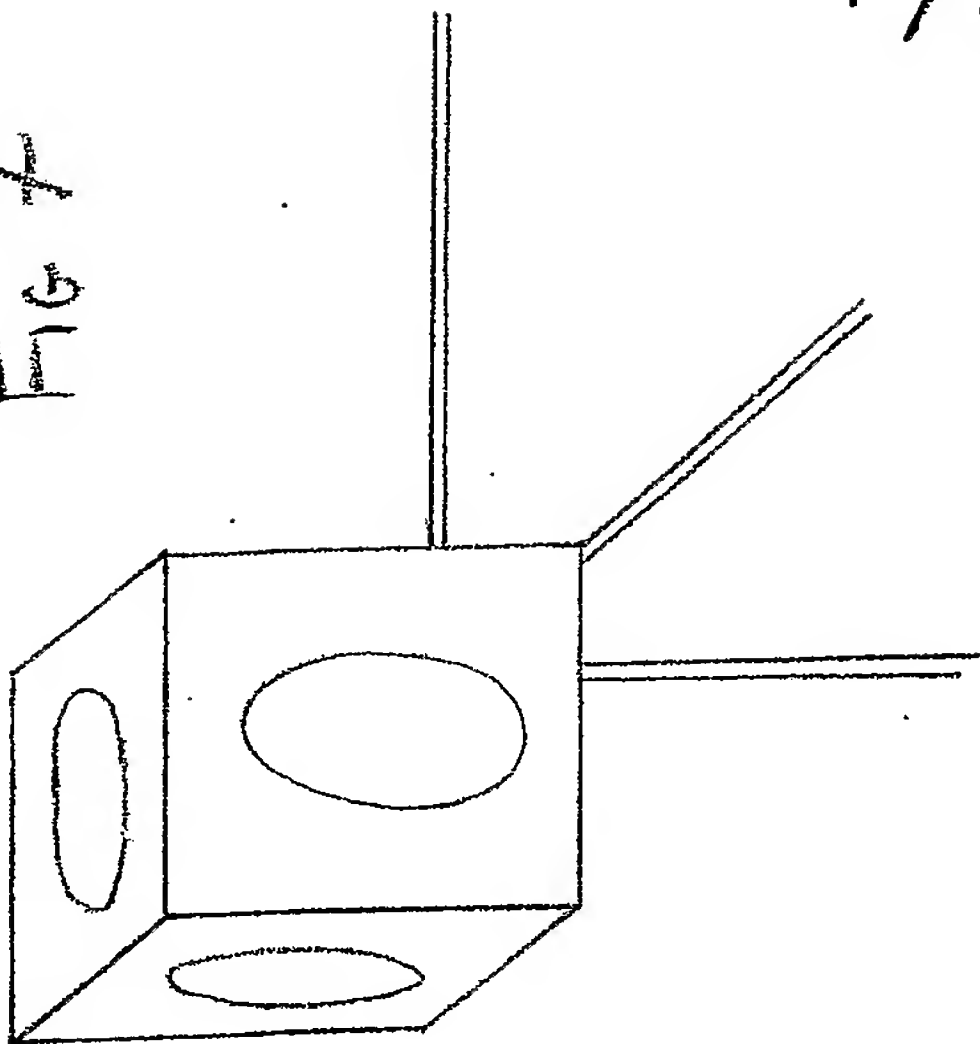


FIG 8

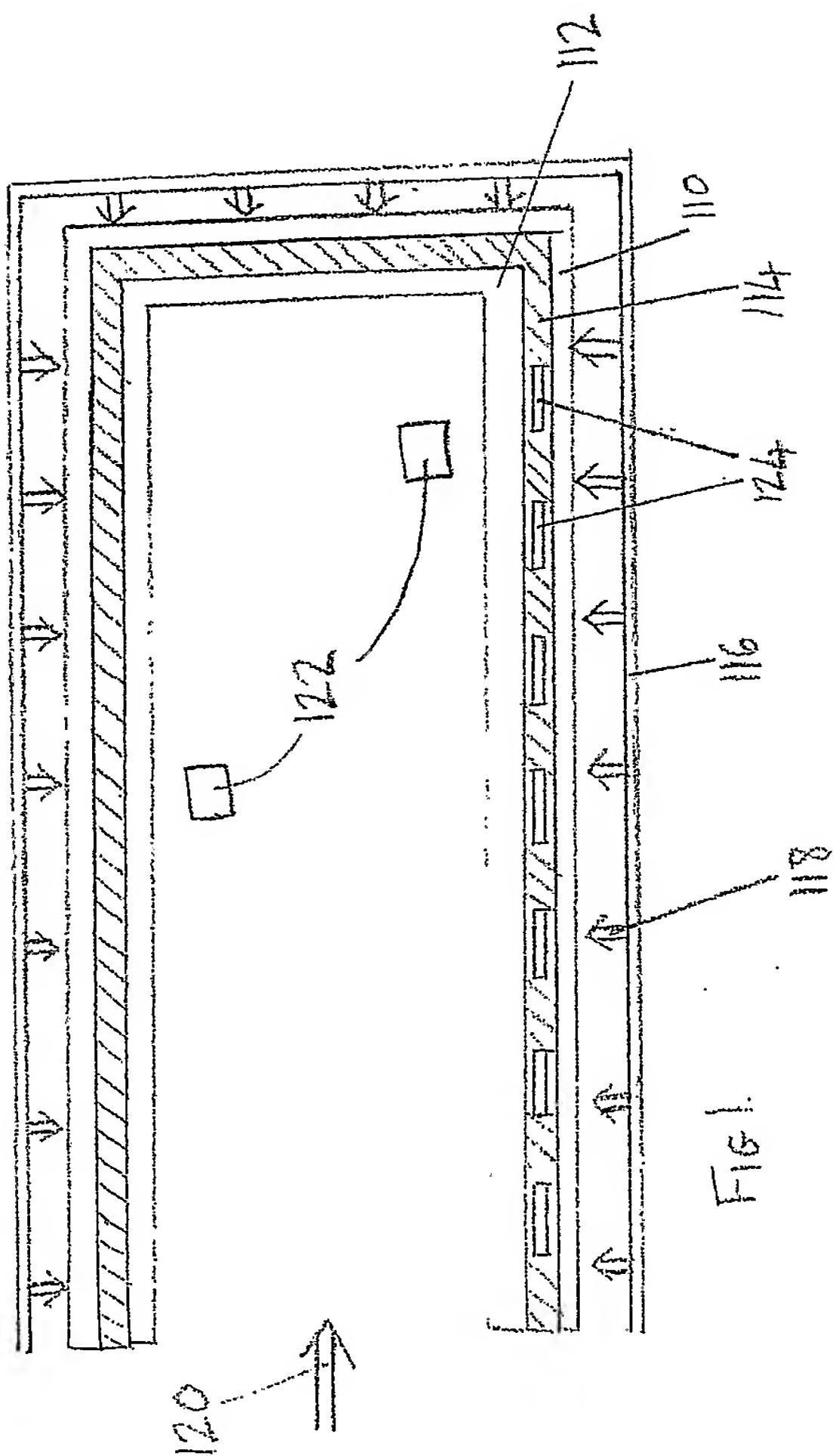
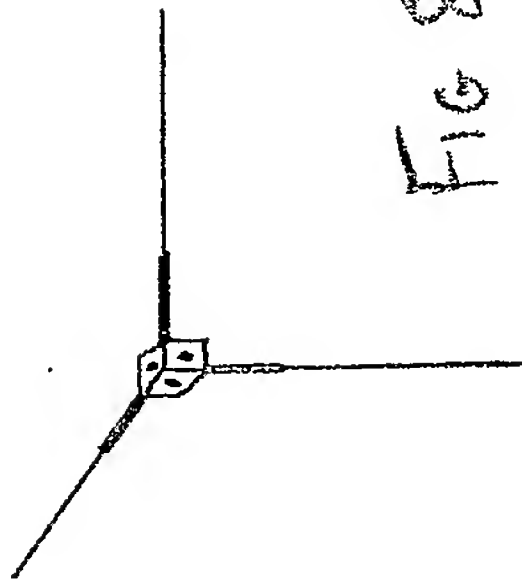
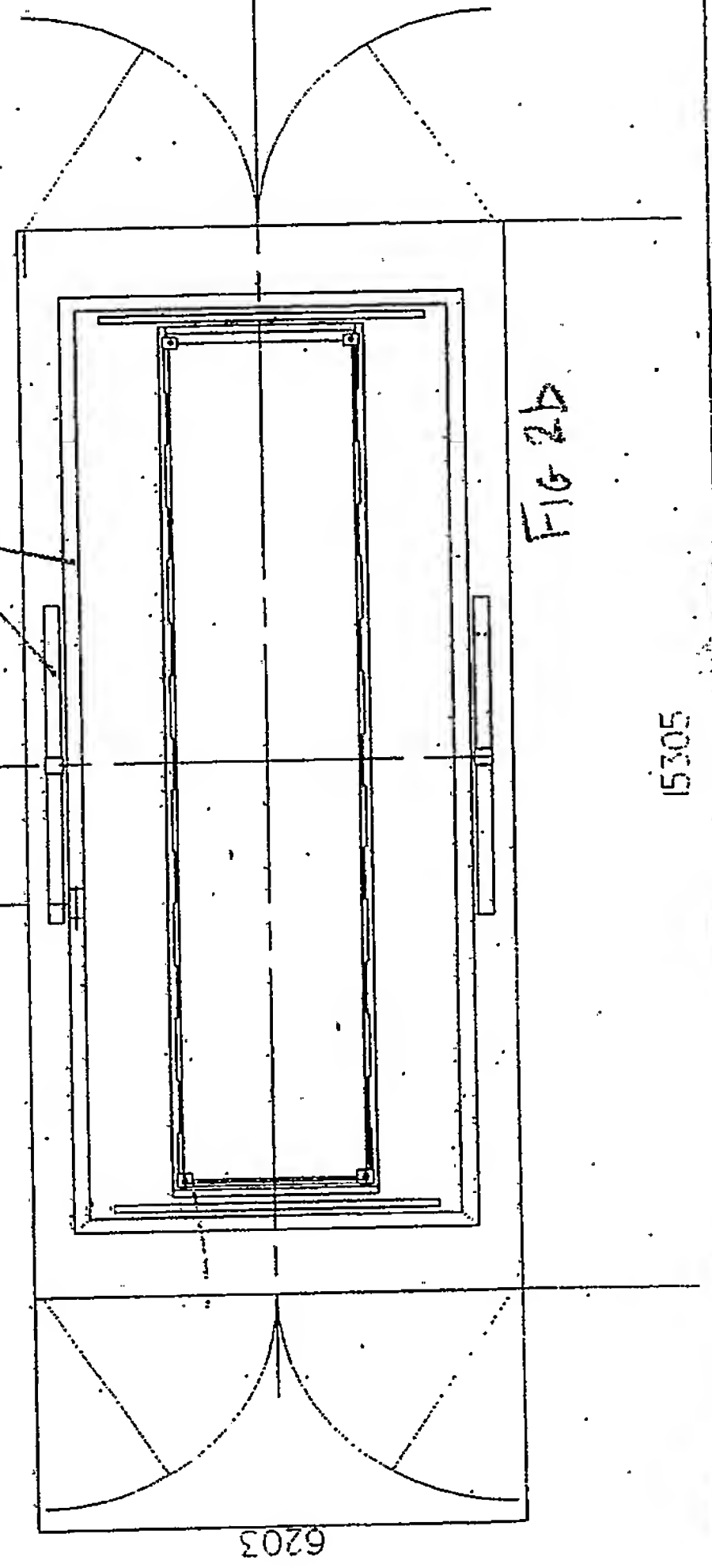
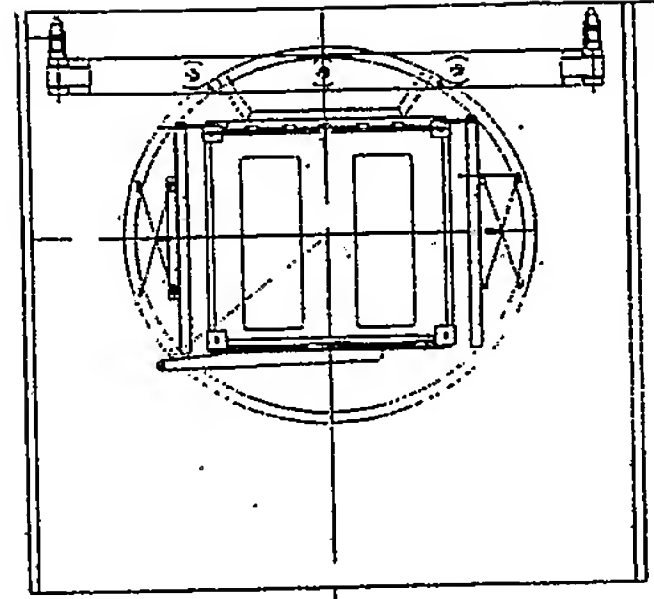


FIG 1.

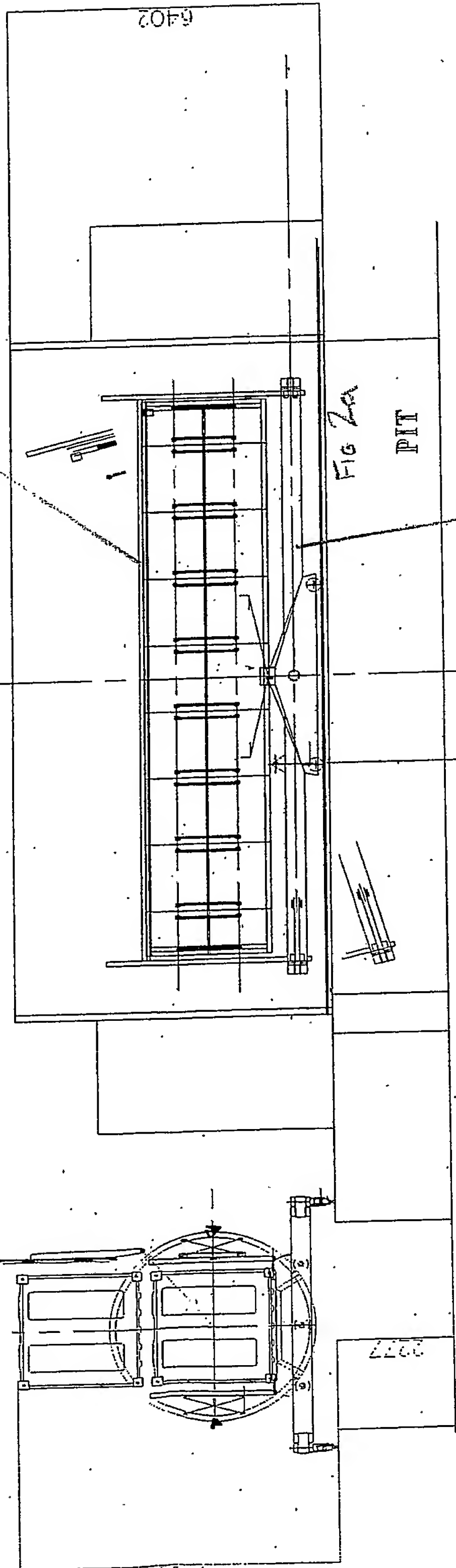




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FIG 2a

PIT

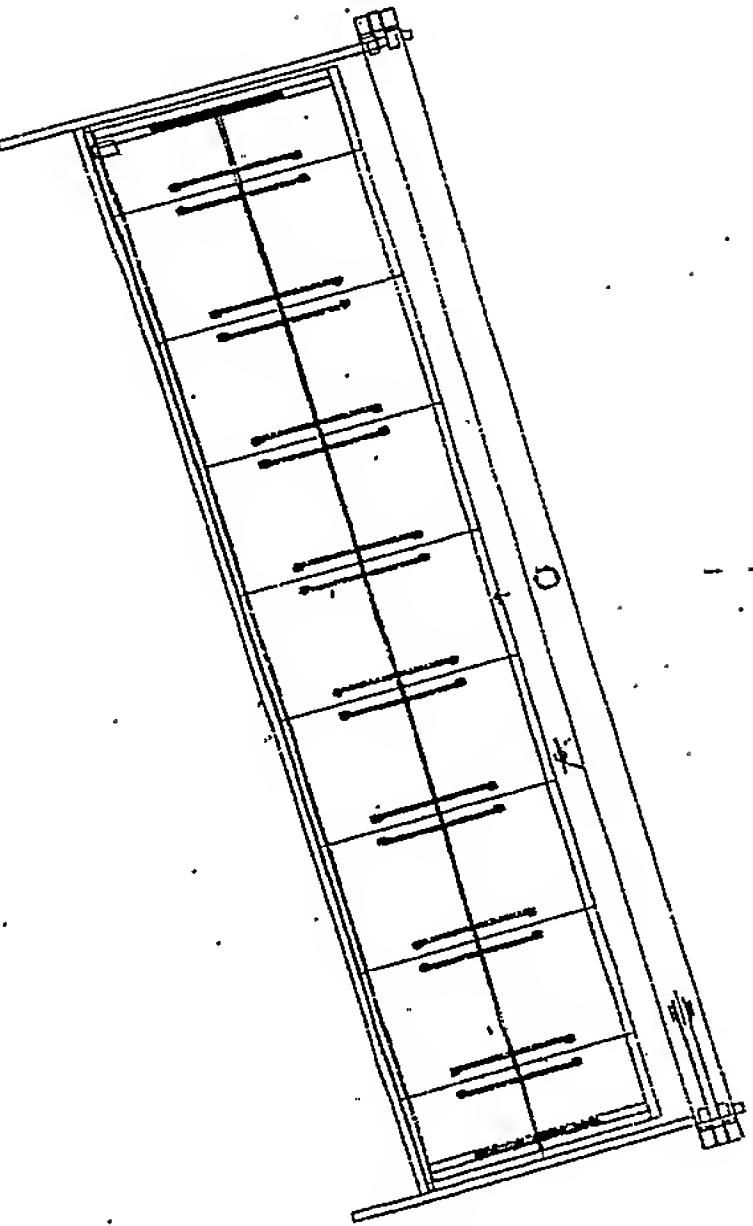
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FIG 2b

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FIG 2c





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FIG. 3

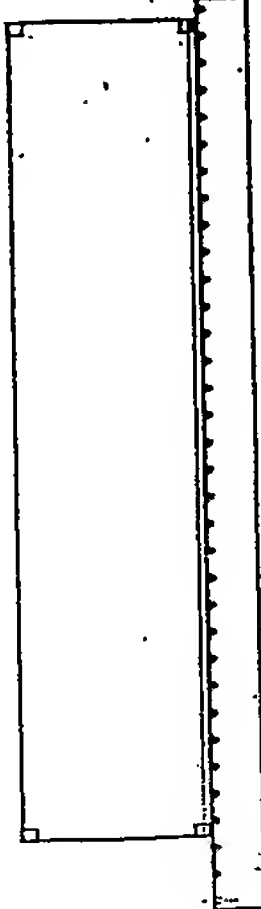
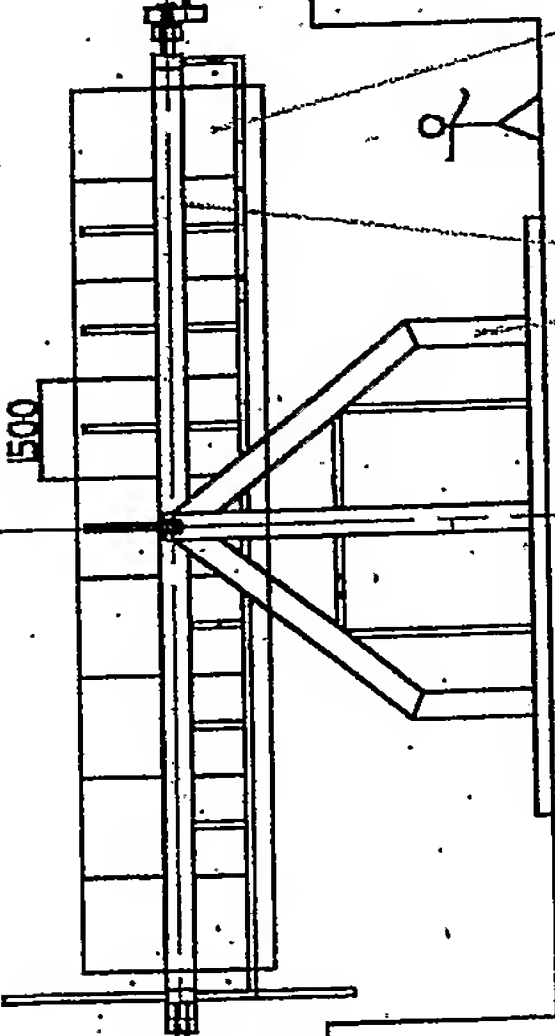
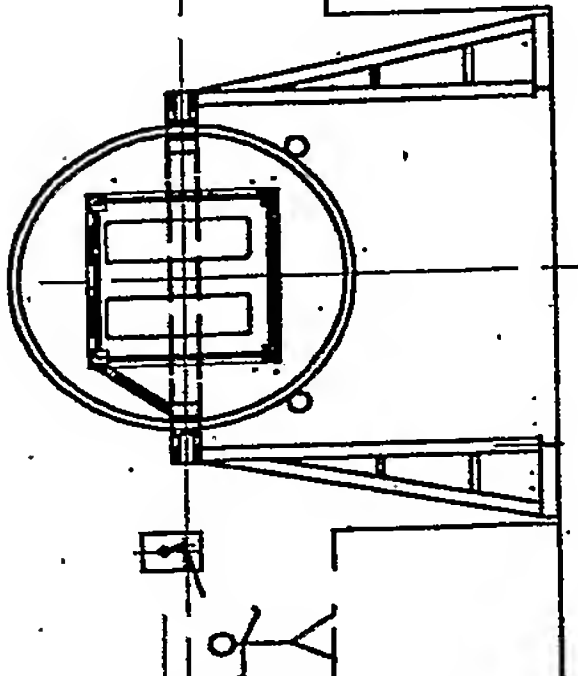
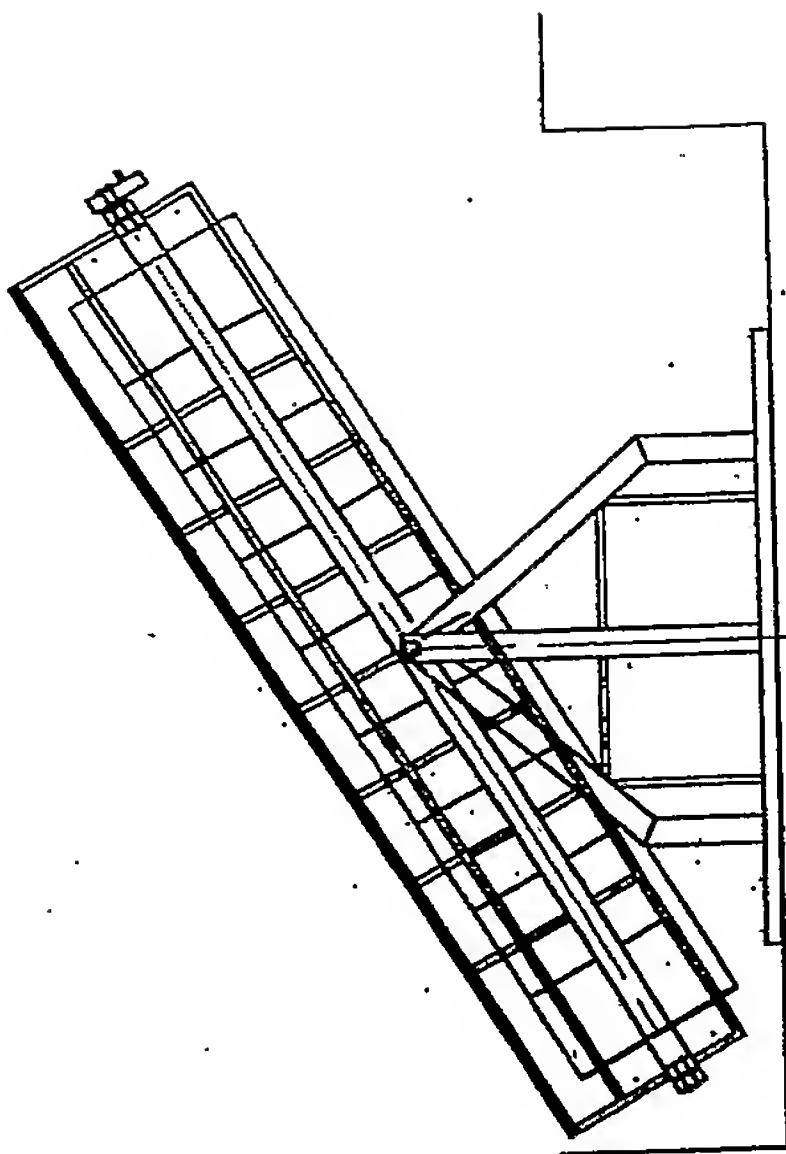
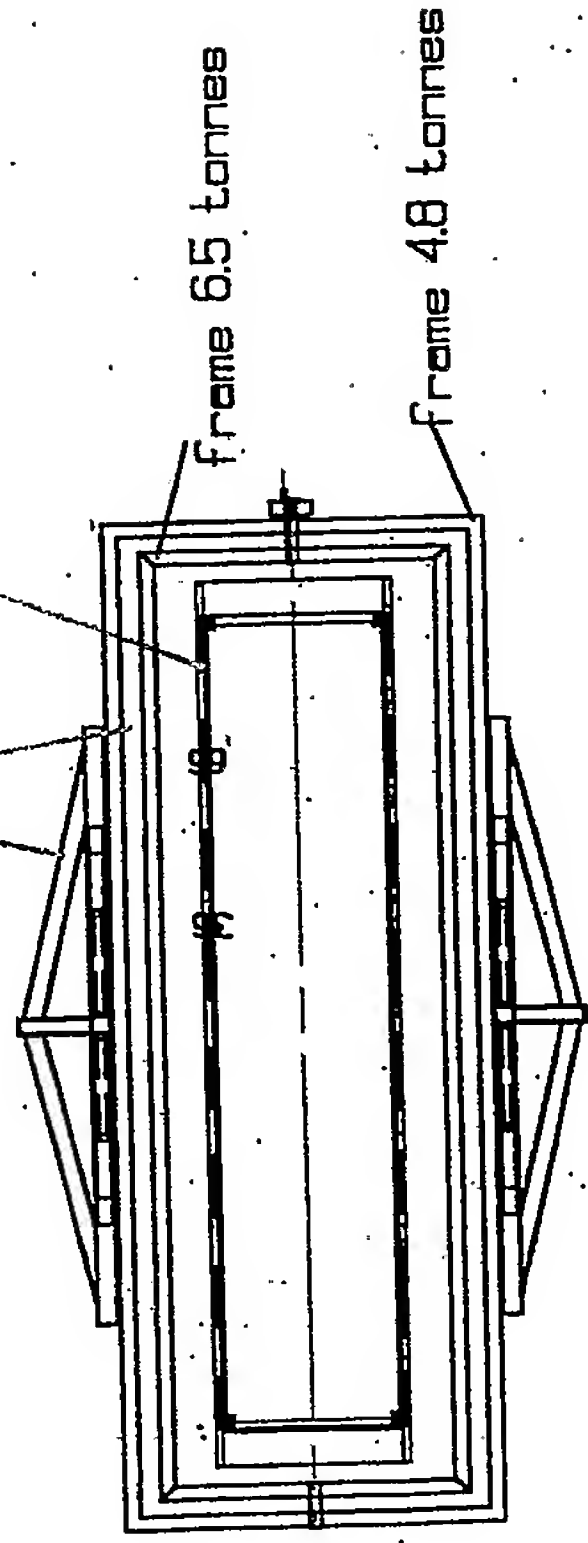


FIG 3

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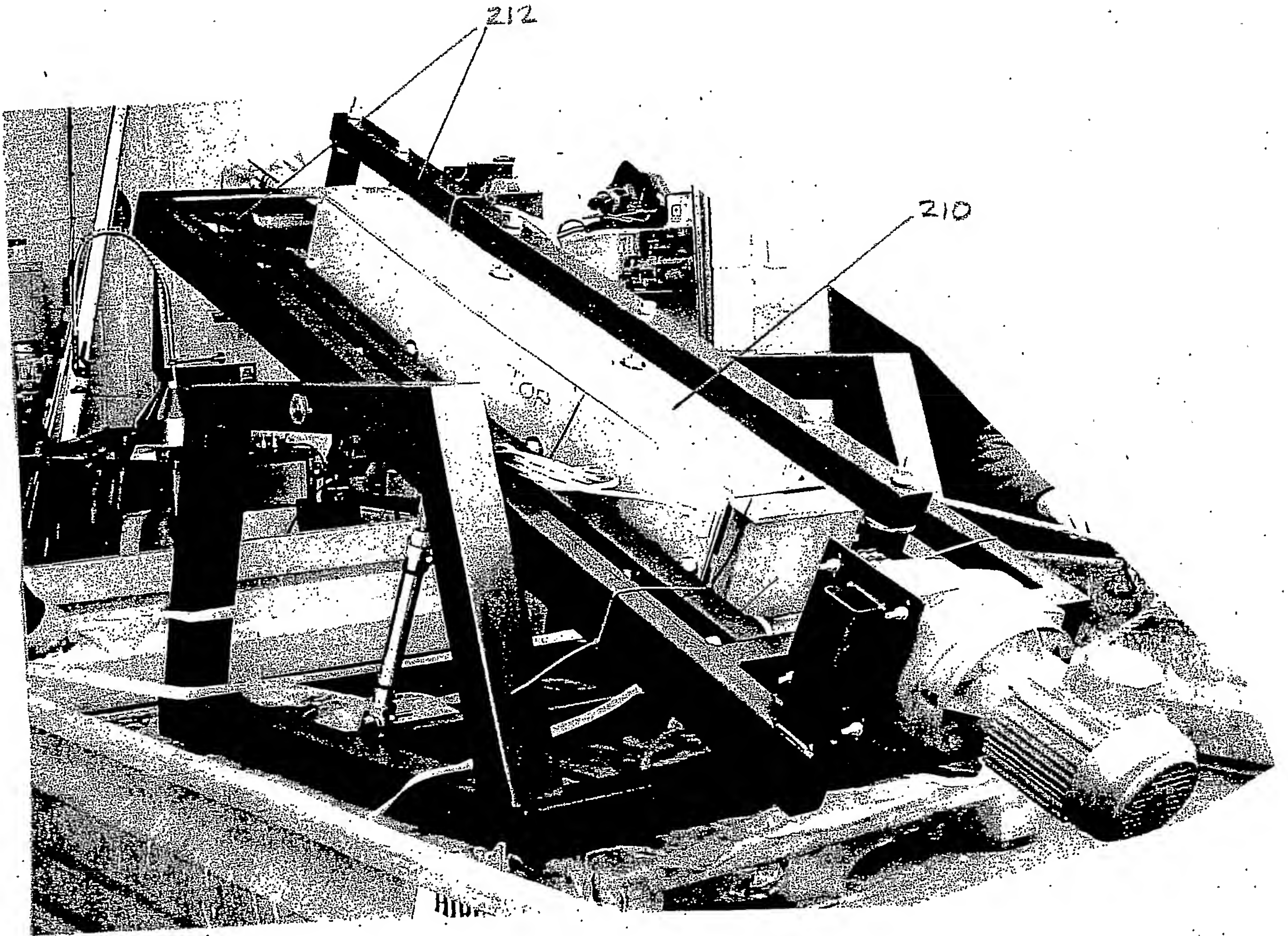


FIG 4





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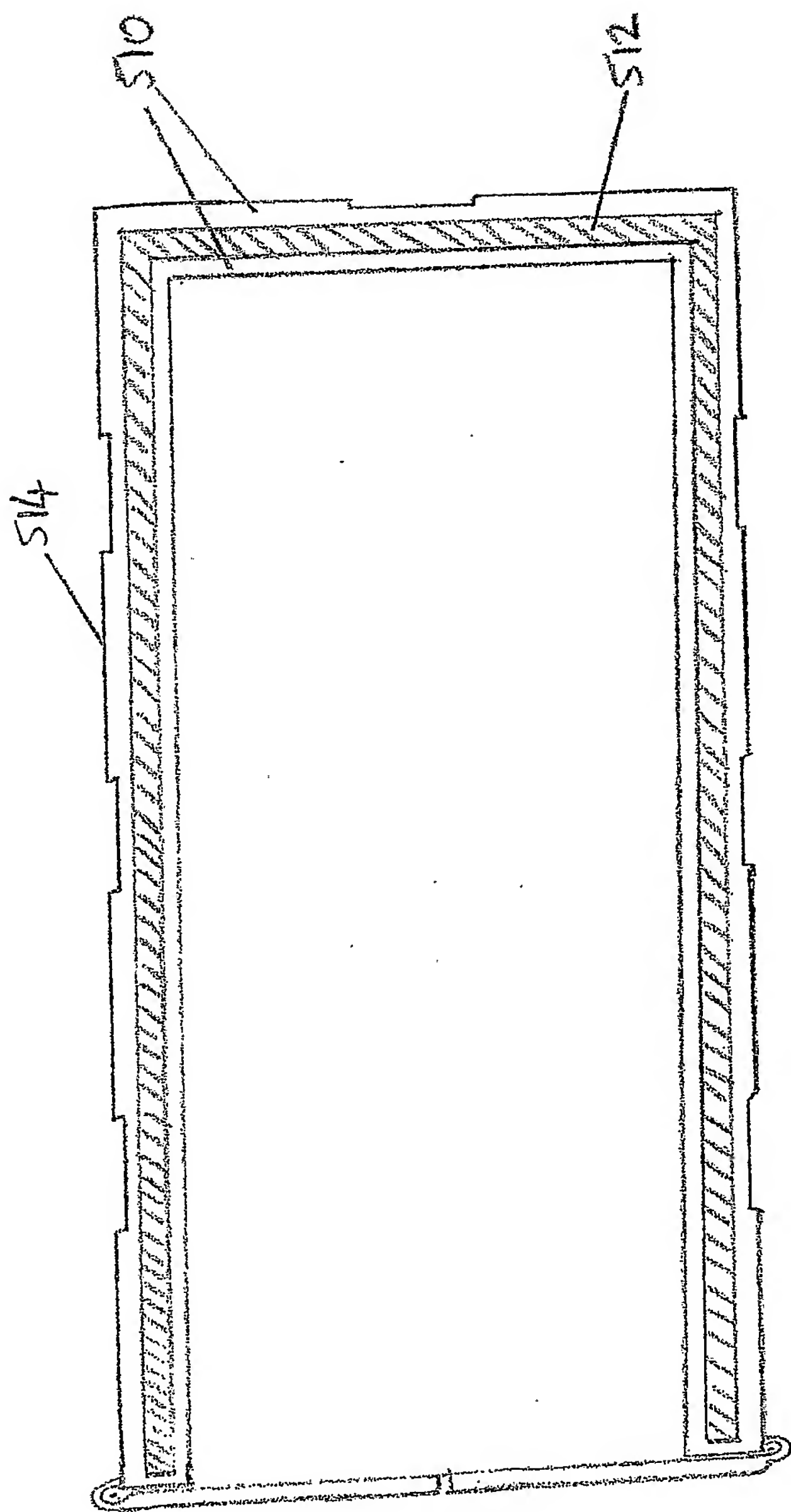


FIG 5



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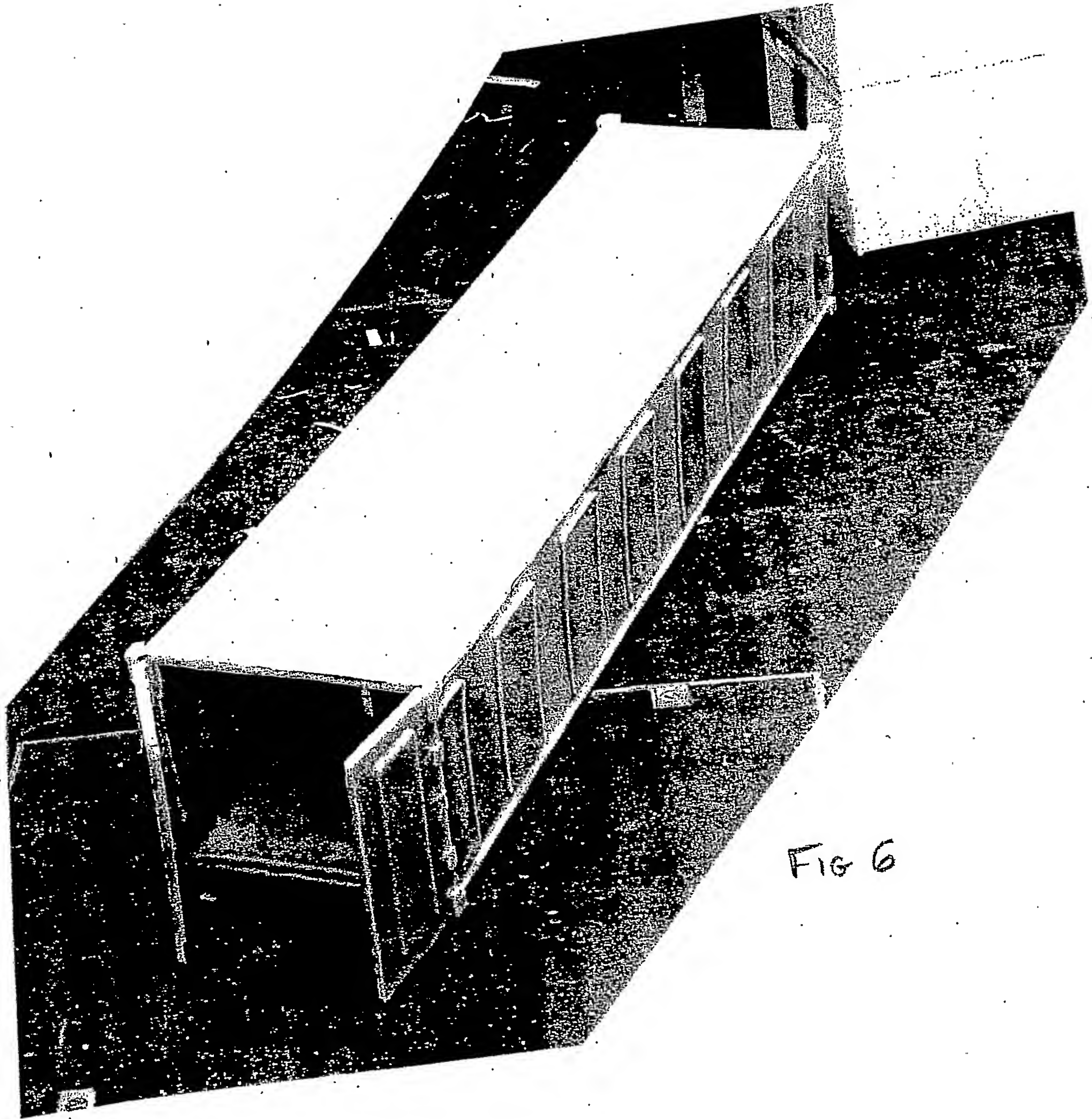
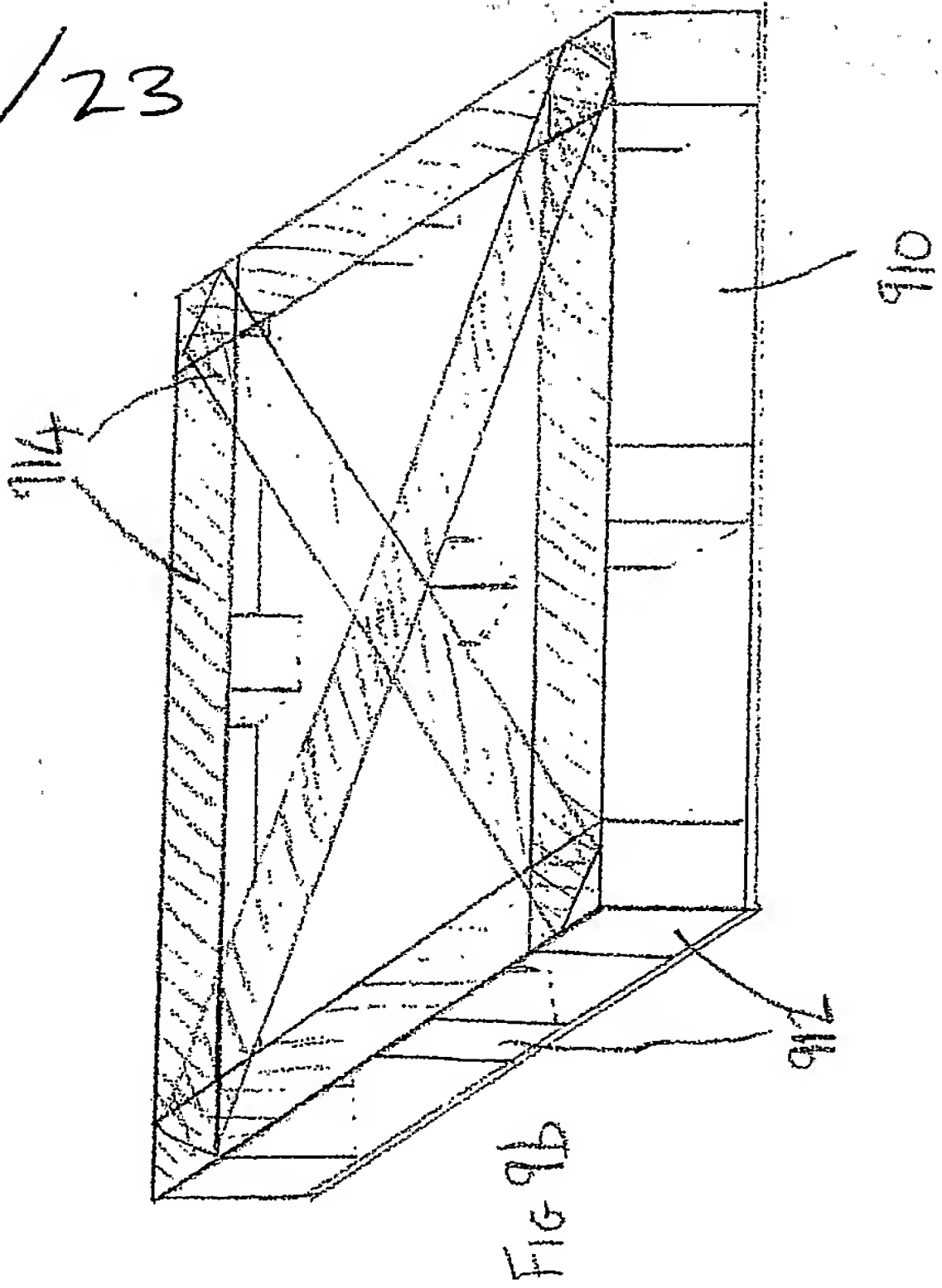
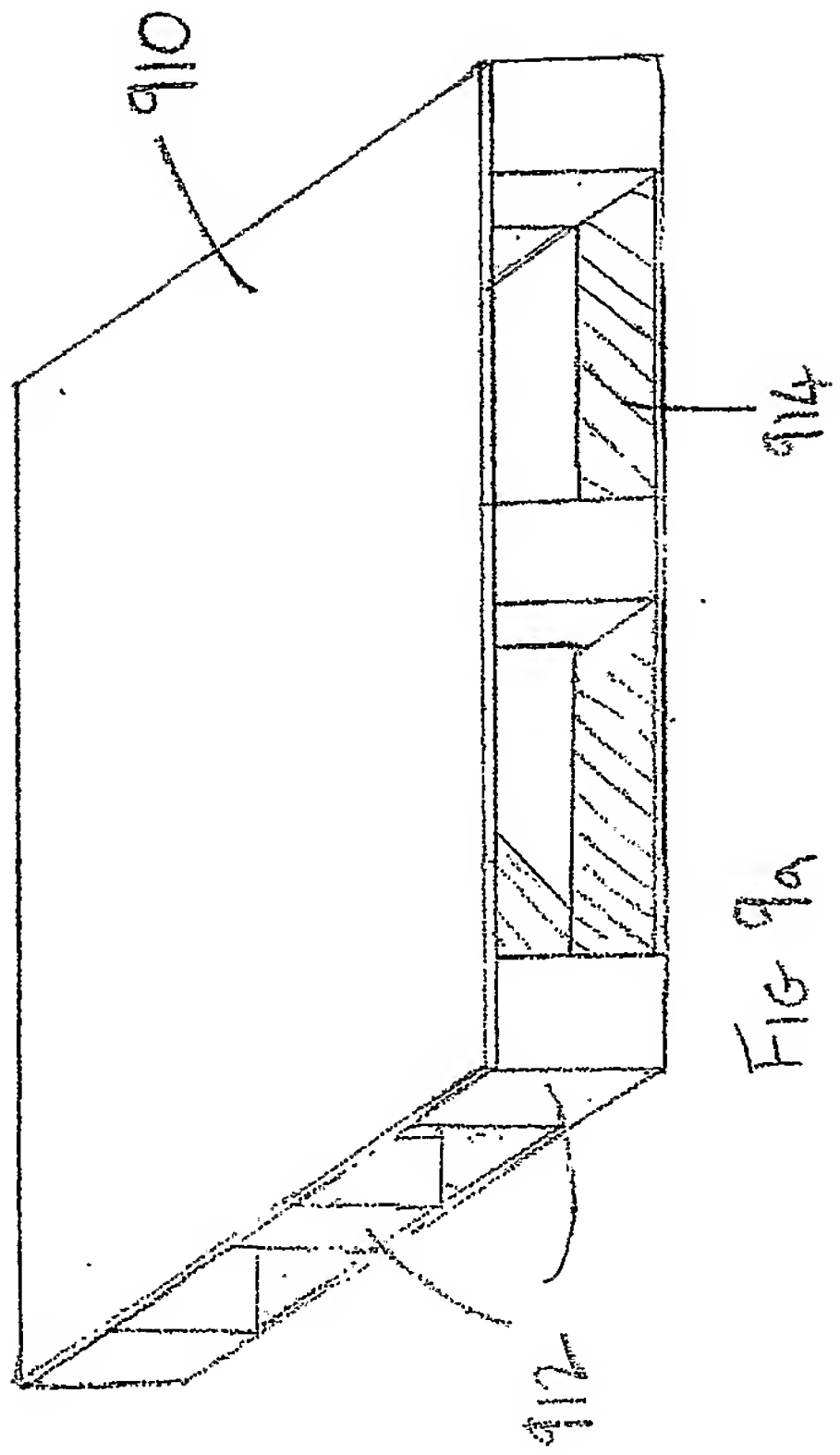


Fig 6





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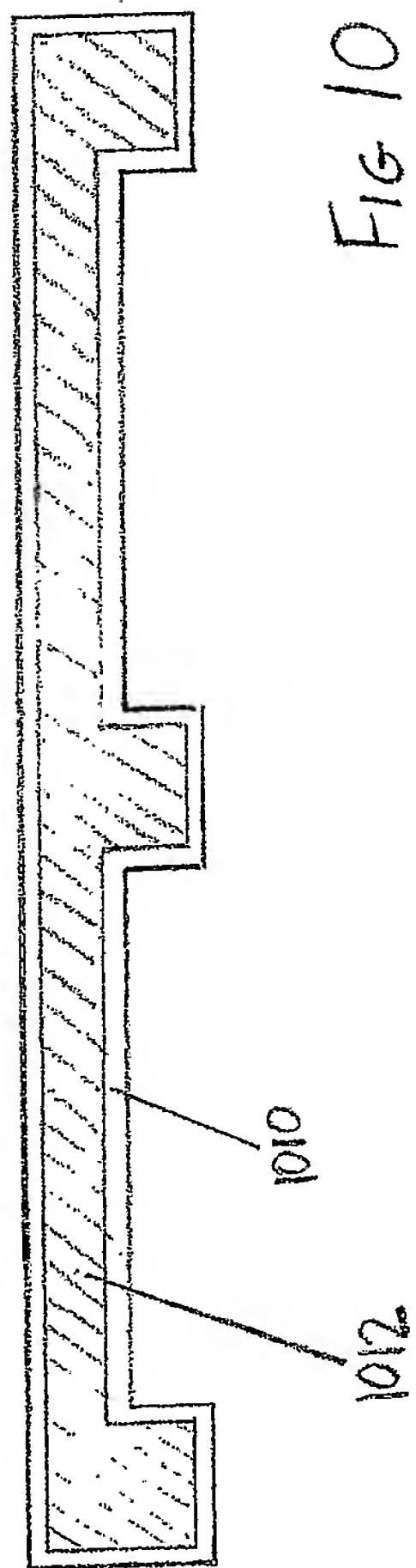


FIG 10



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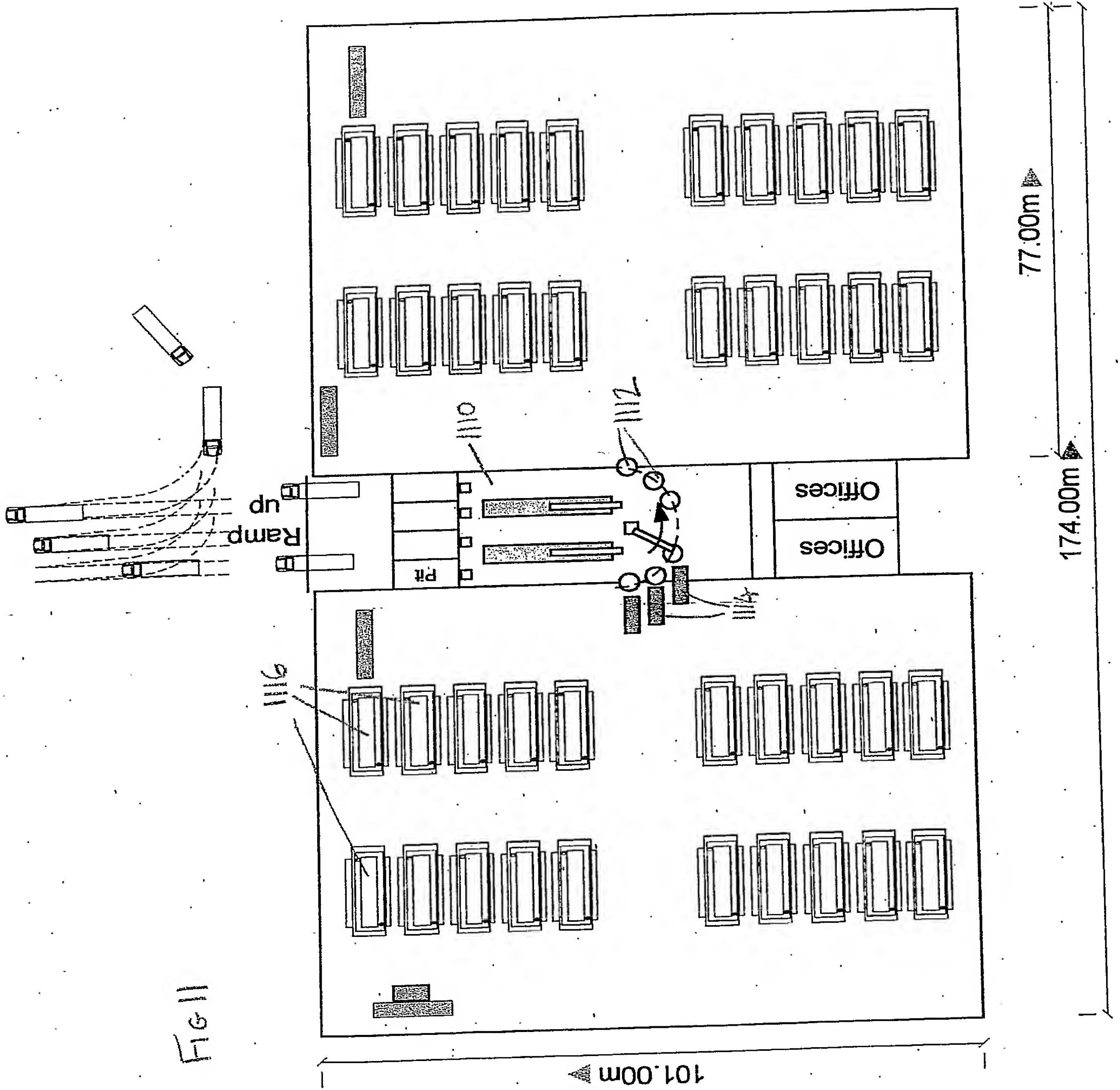
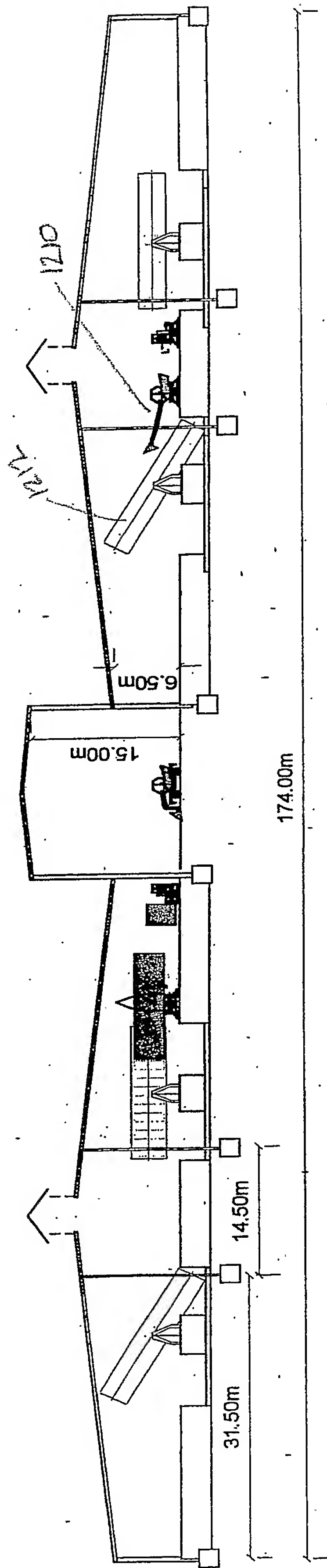


Fig 11

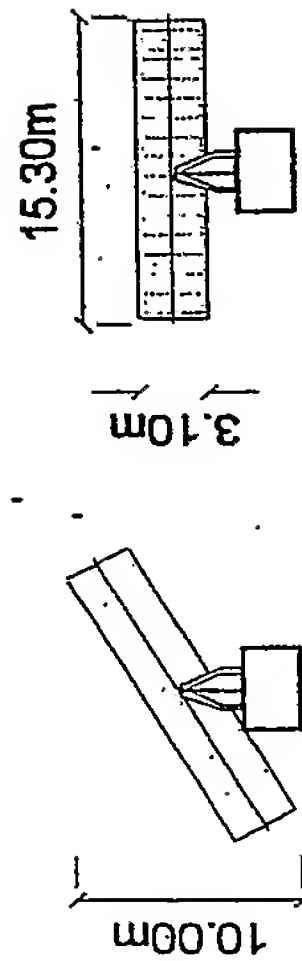






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FIG 12





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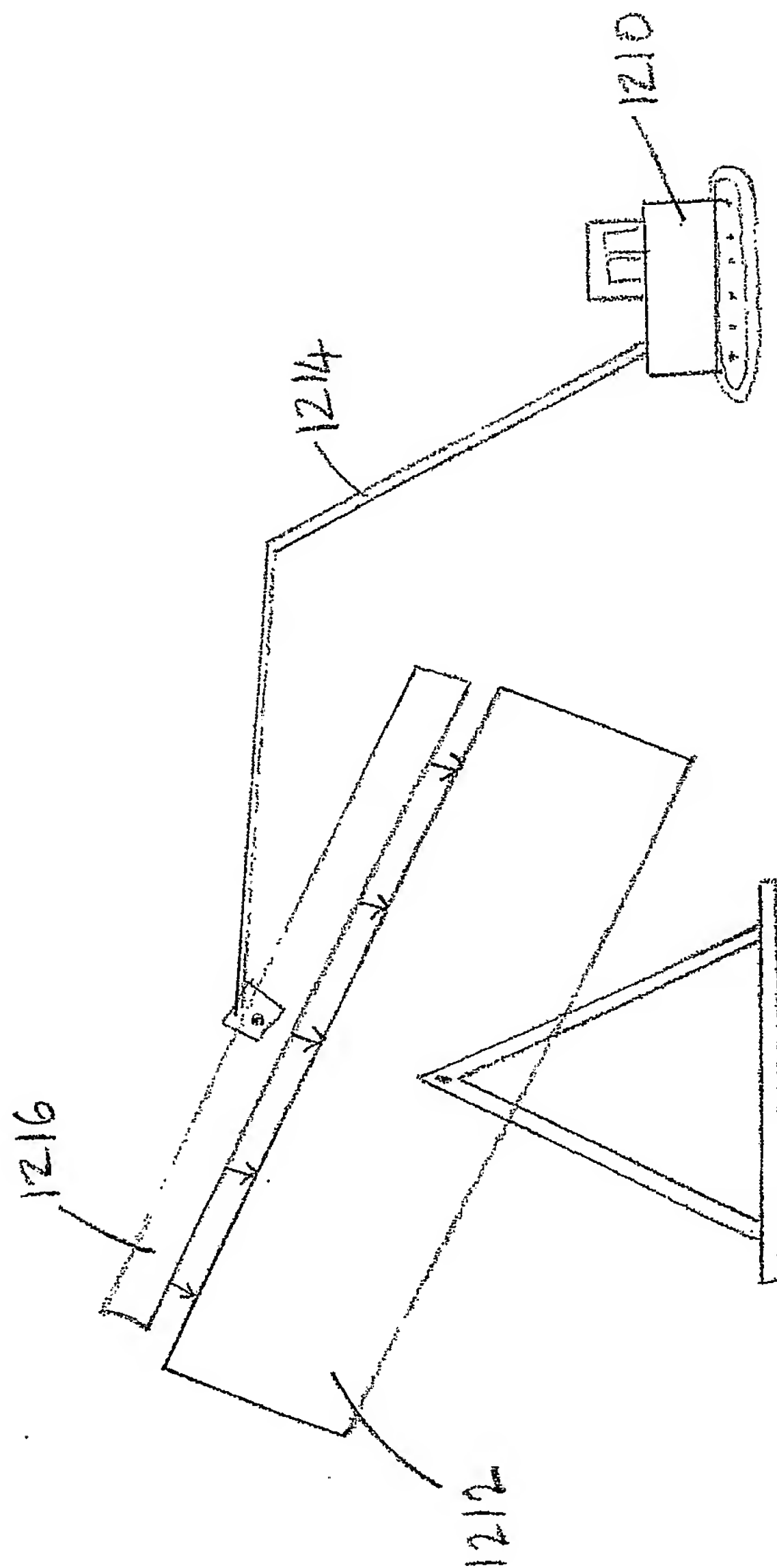
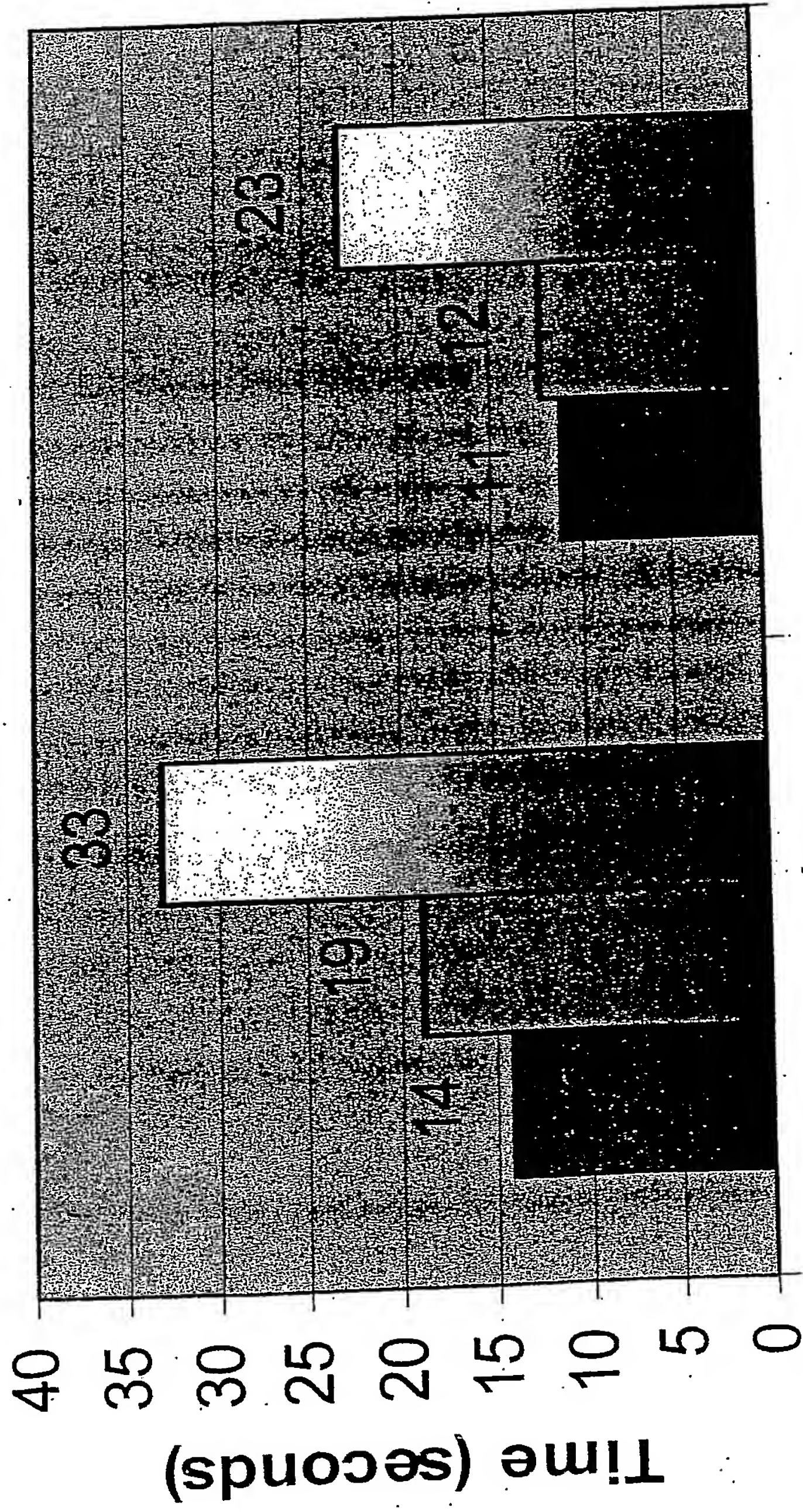


FIG 13



# Cycle Times Polyethylene vs composite.



- Heat up Time
- Cool down Time
- Total Time

Polyethylene composite

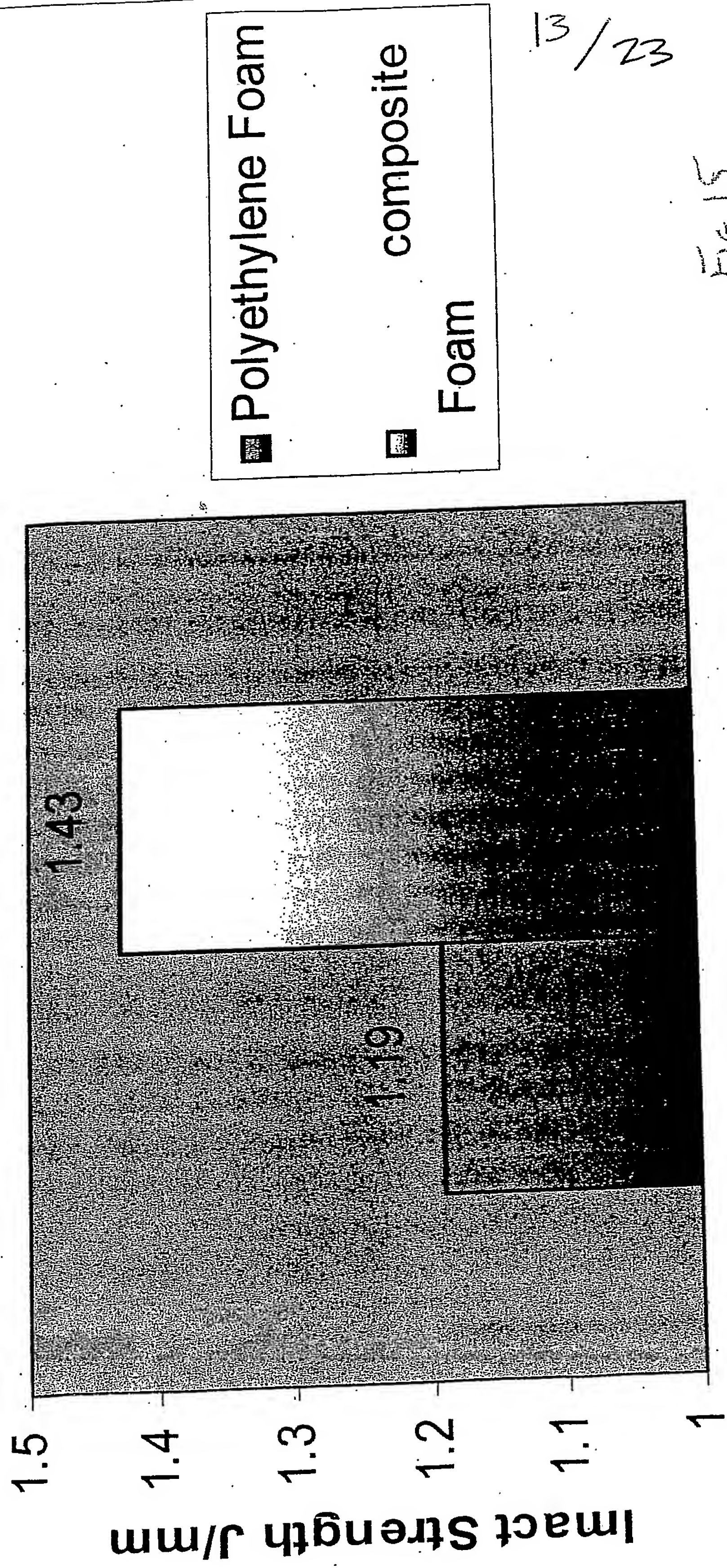
Fig 14

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# Impact Strength of Polyethylene Foam





# Tensile Modulus of composite vs Polyethylene



Fig 16

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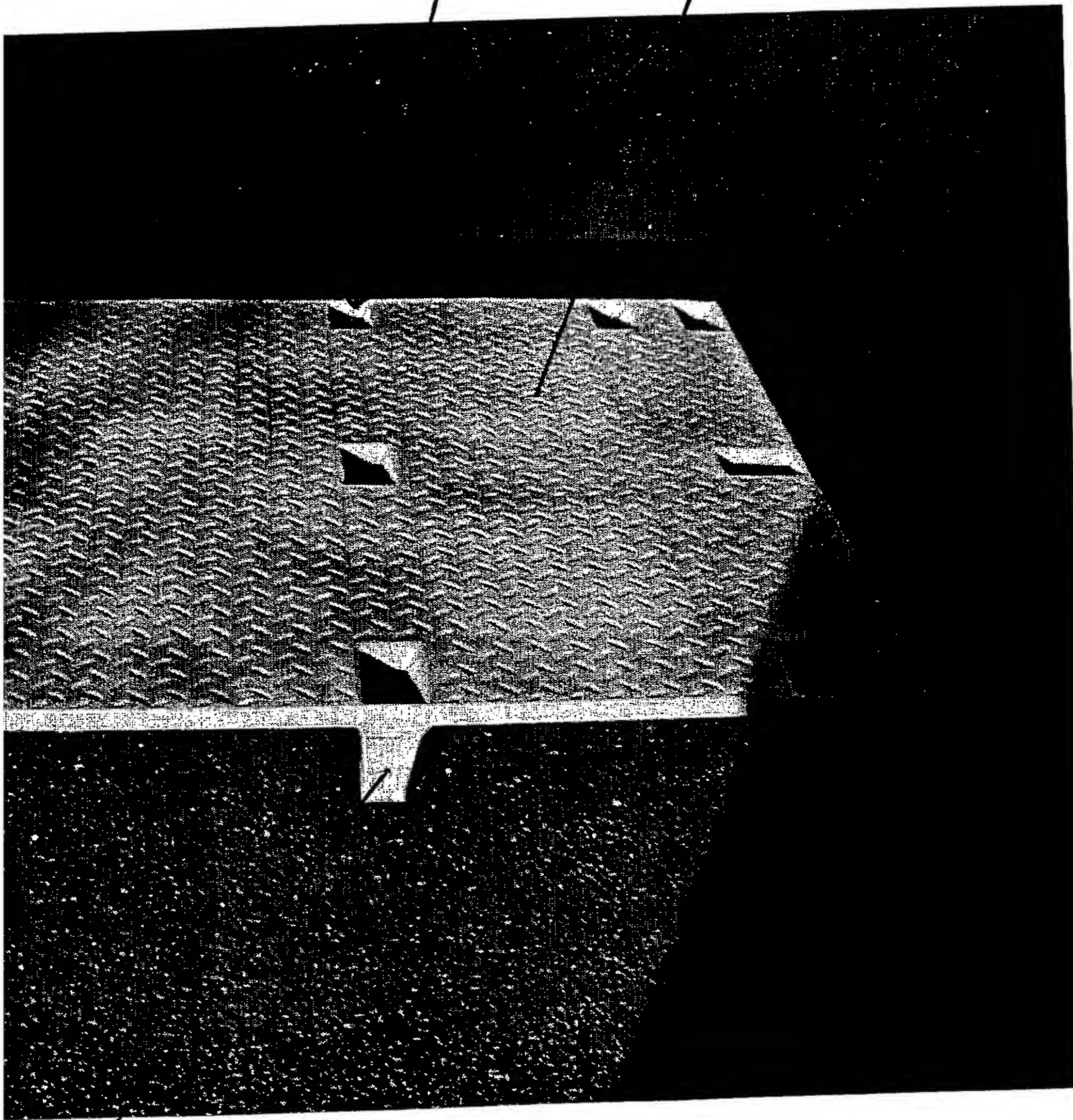


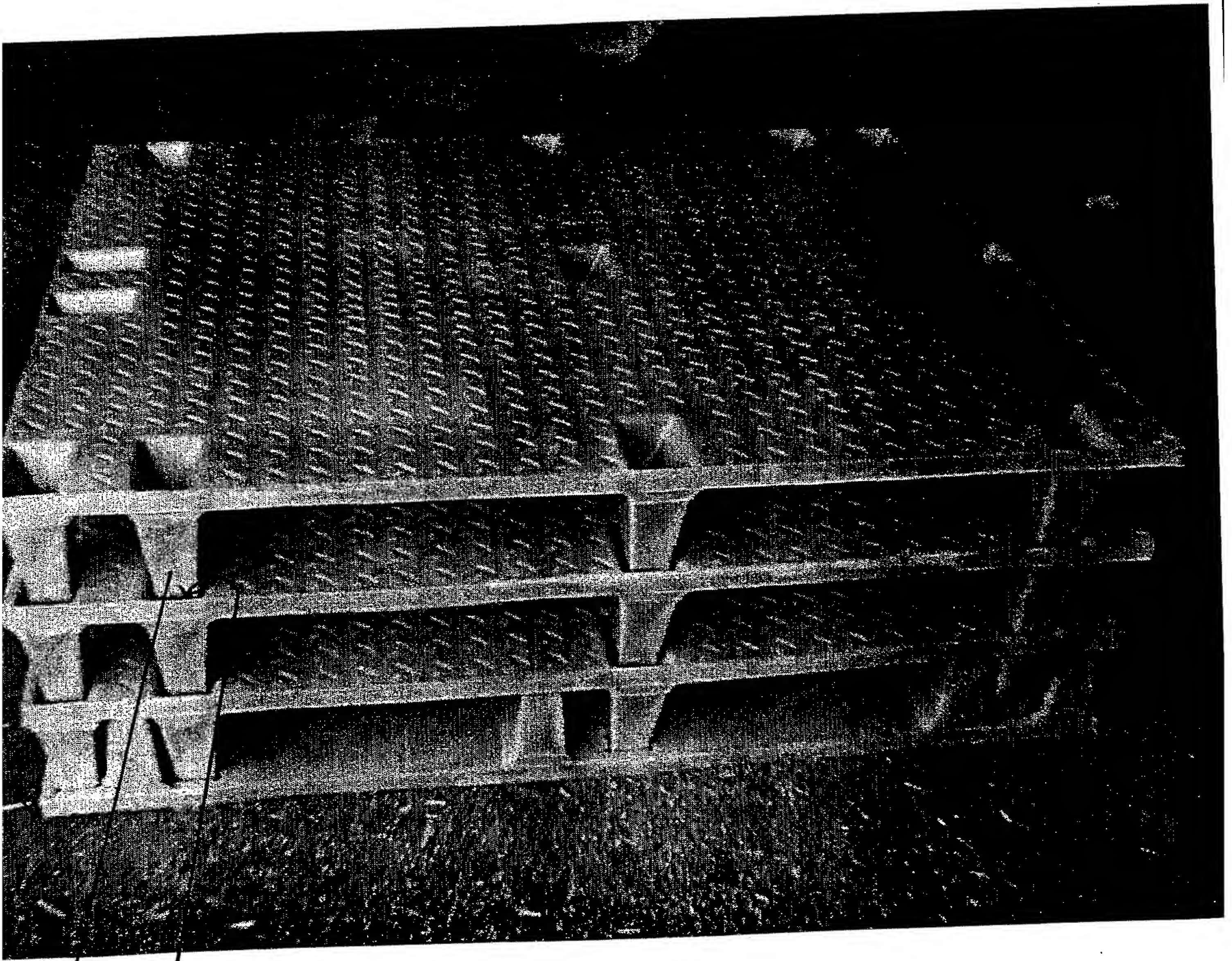
FIG 17

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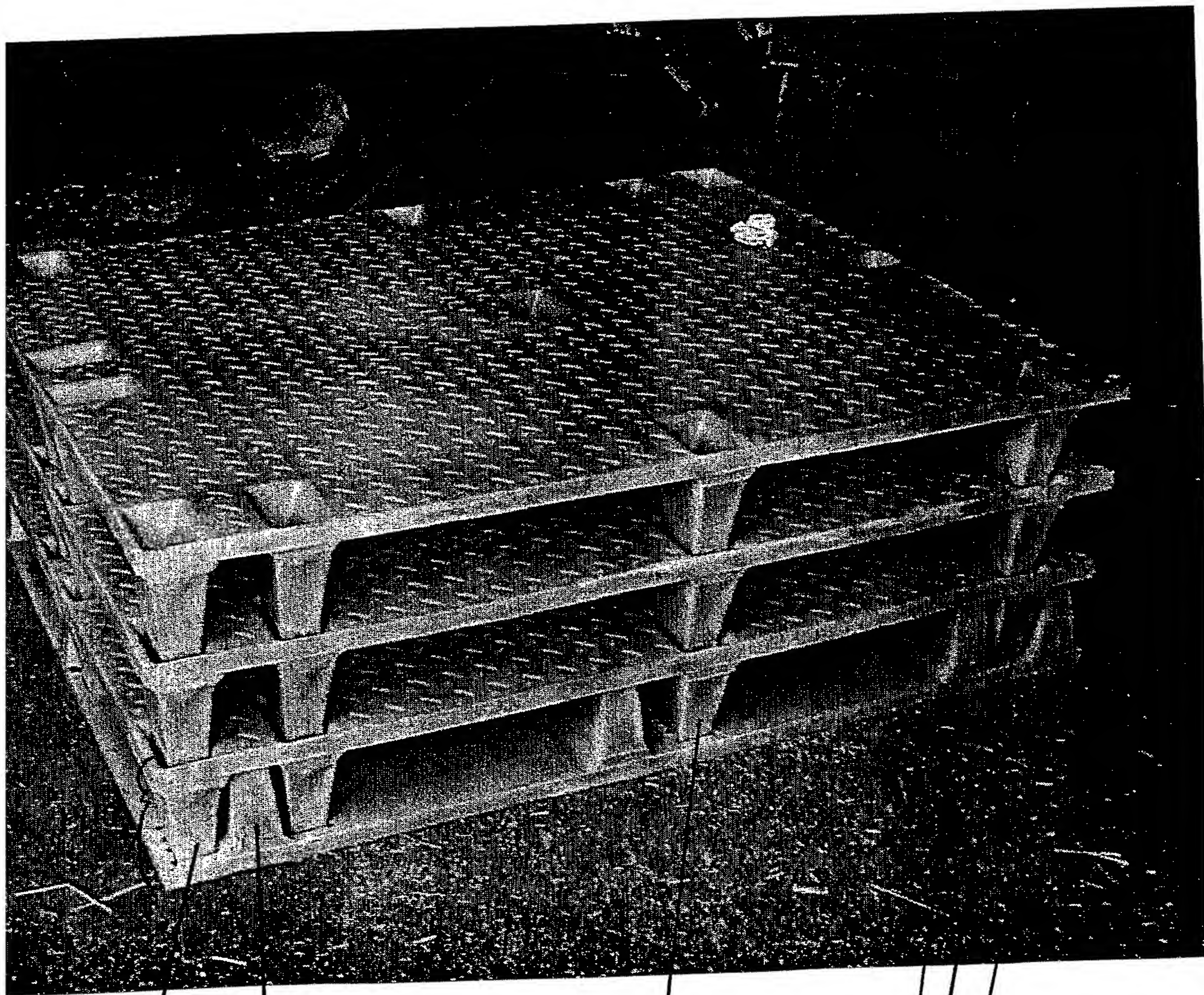
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FIG 18





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Fig 19

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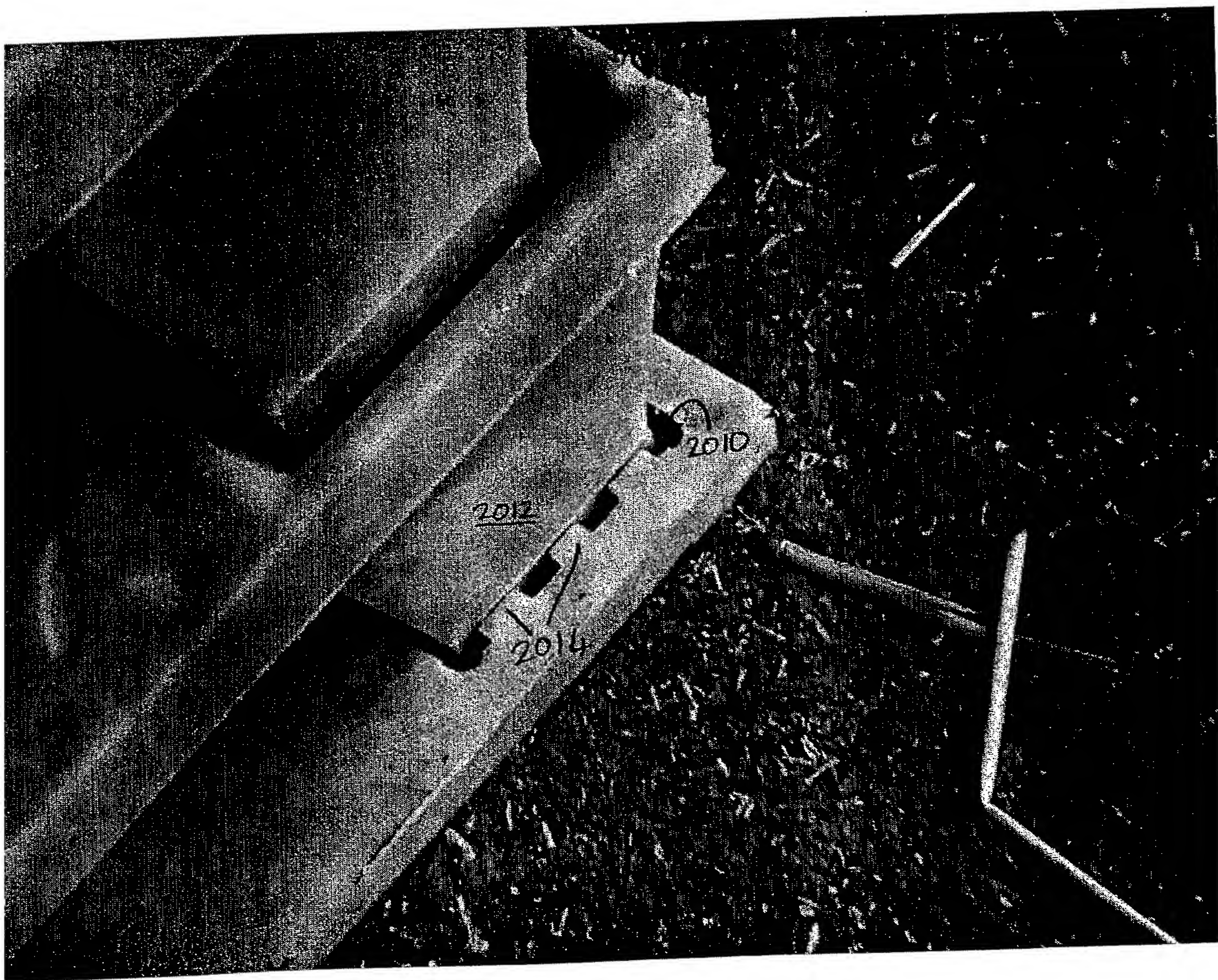


FIG 20





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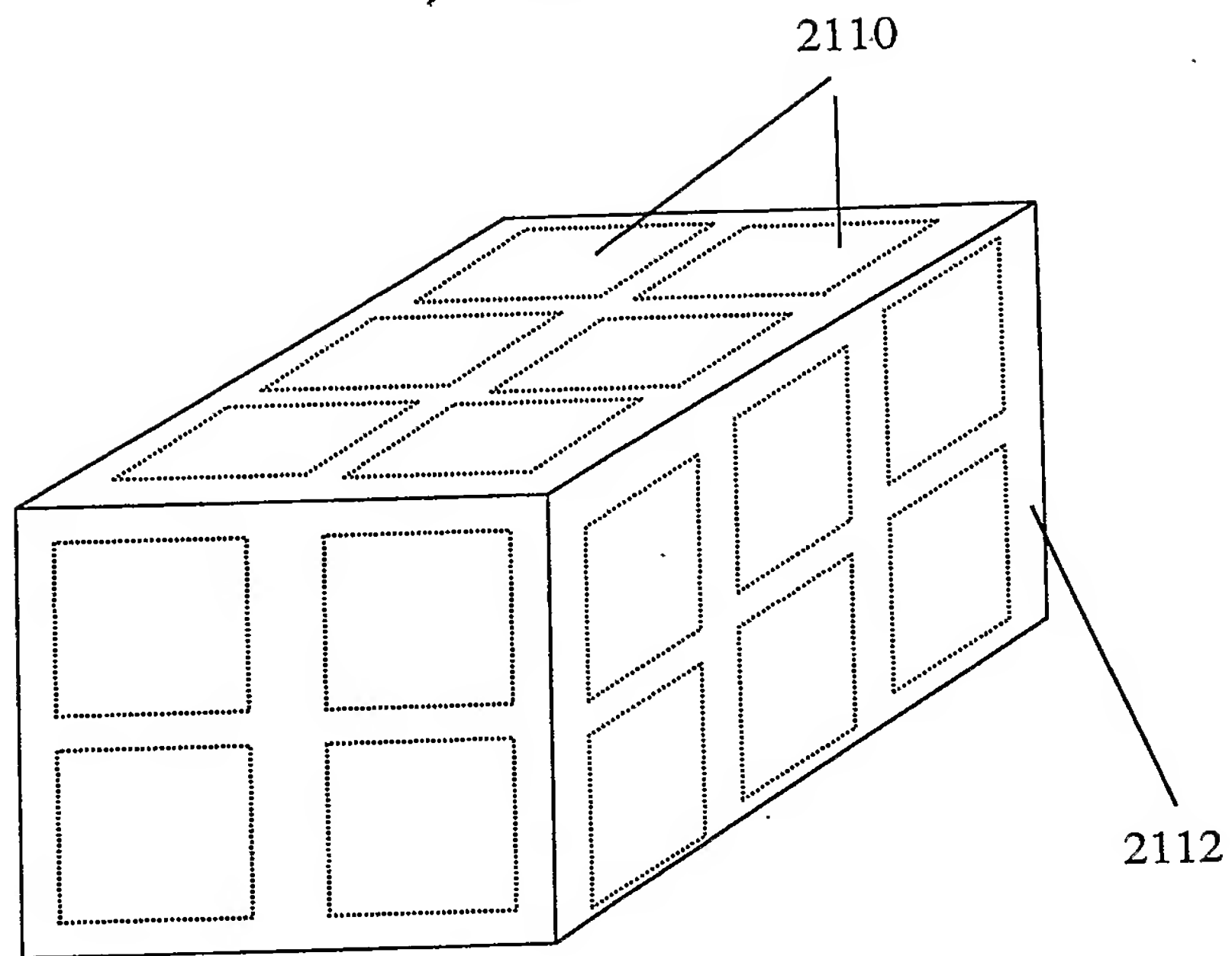
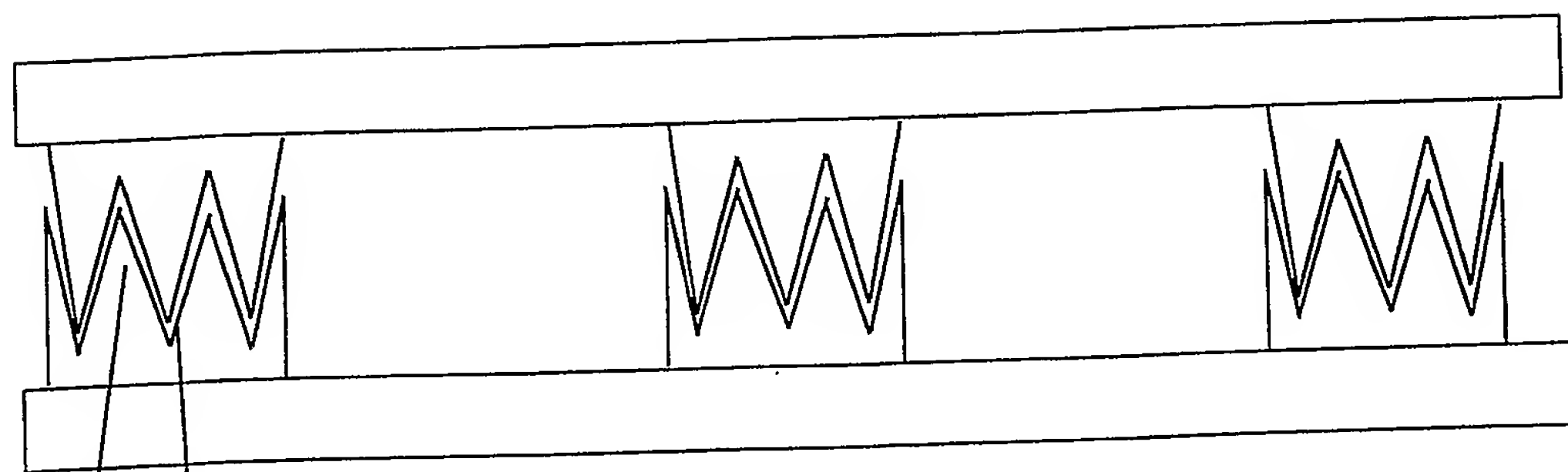


Fig. 21



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Fig. 24



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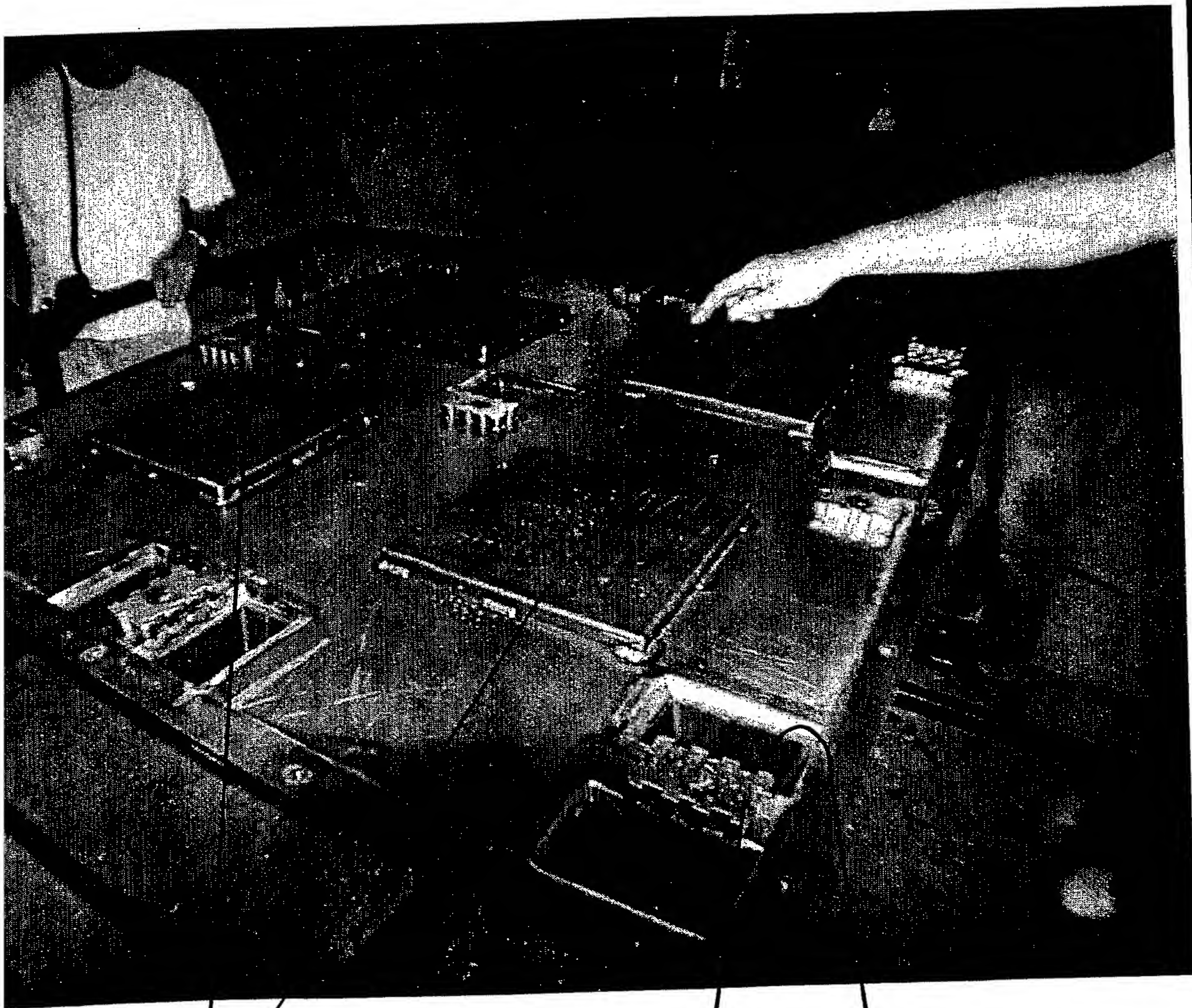


FIG 22

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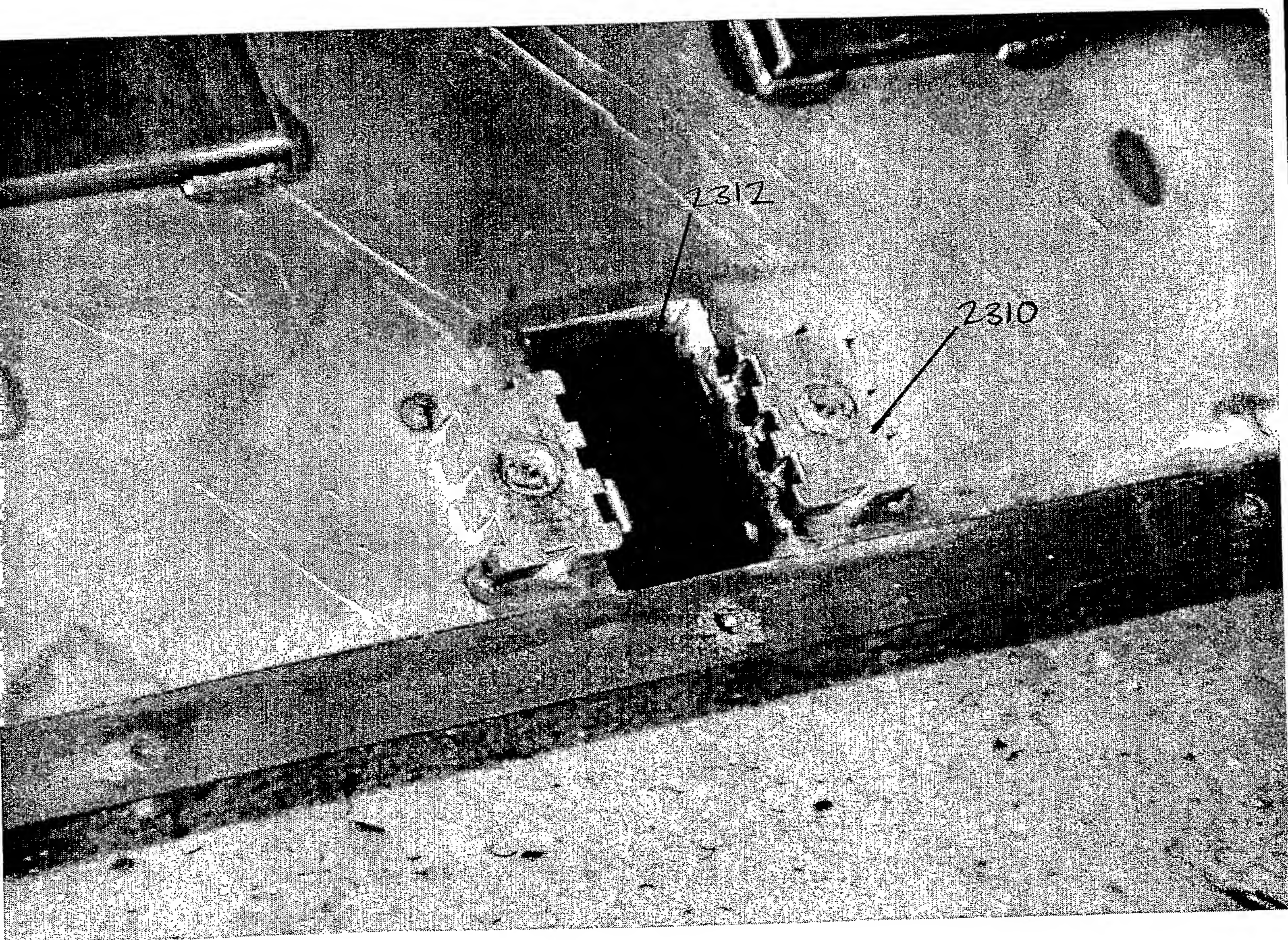
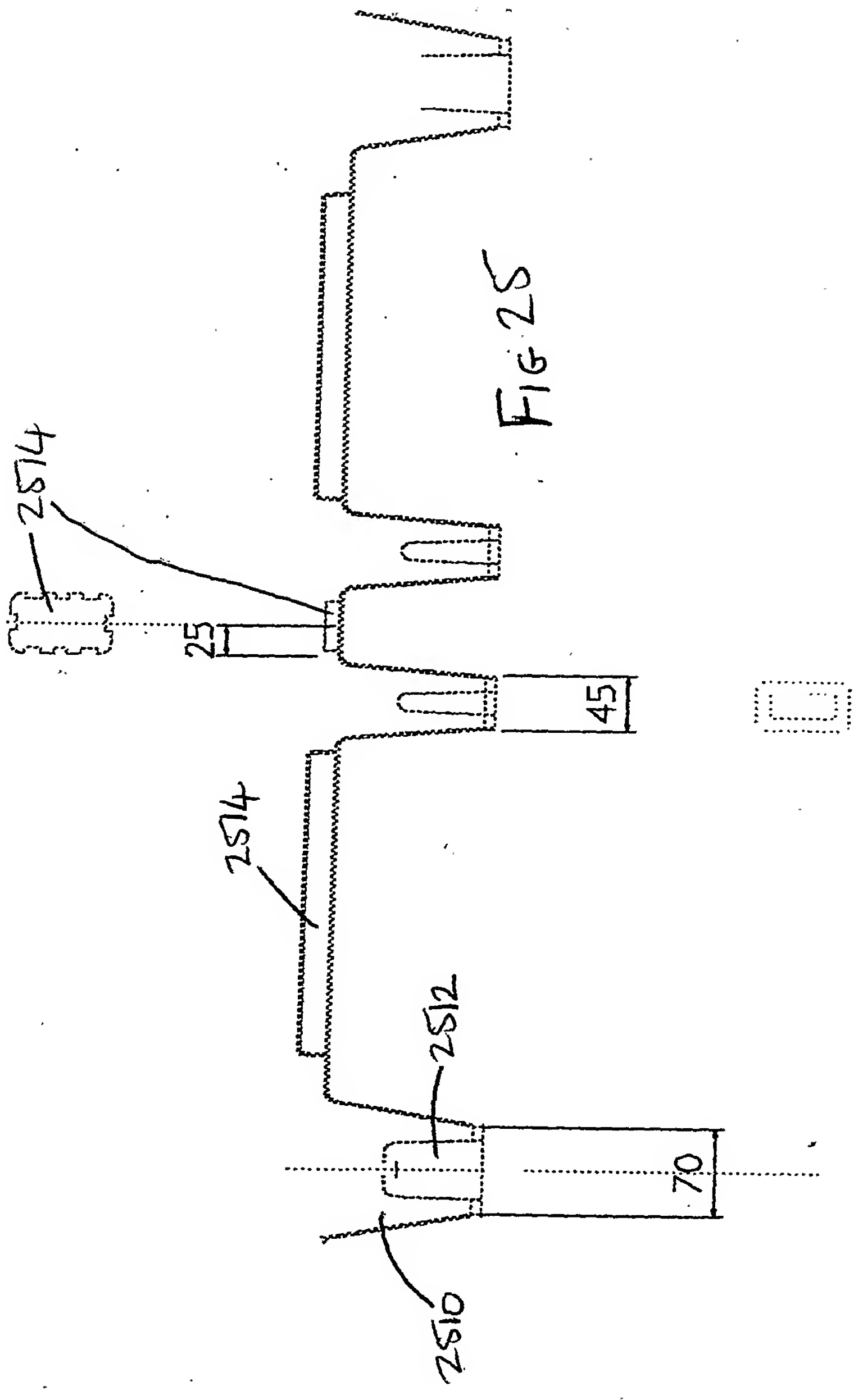
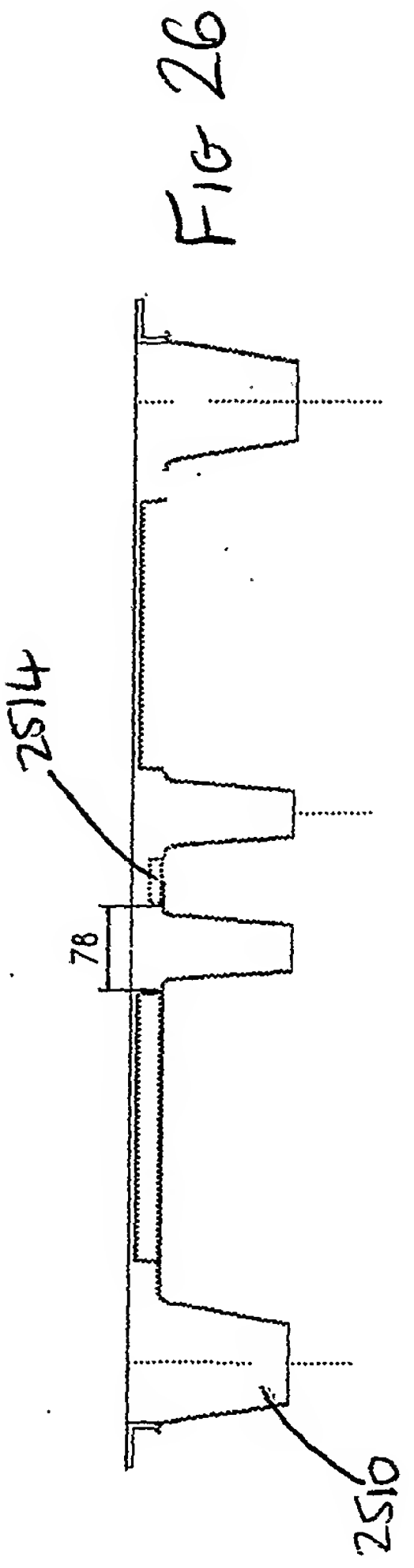


FIG 23





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SECTION

